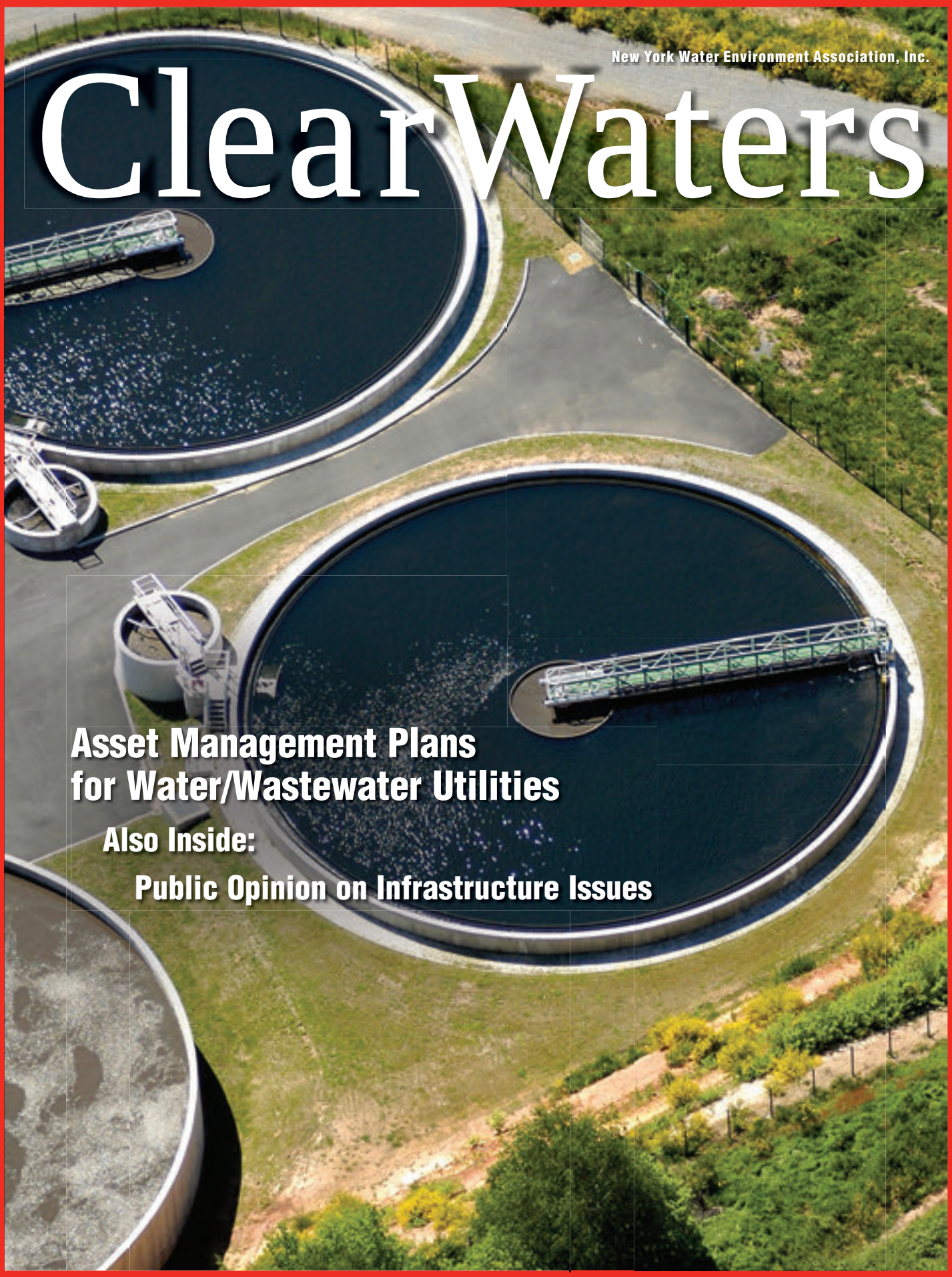
Winter 2013, Vol. 43, No. 4

New York Water Environment Association, Inc.

ClearWaters



Asset Management Plans for Water/Wastewater Utilities

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Clear Waters

New York Water Environment Association, Inc.

Cover Image: This issue describes how the complex assets of water/wastewater treatment facilities can be better managed – here, an aerial view of wastewater purification works basins.

Photo credit: istock by Getty

The concepts, ideas, procedures and opinions contained in the articles in this publication are those as expressed by the various authors who submit the material for publication. The New York Water Environment Association, its board of directors, the editor, the executive director, and administrative staff hereby assume no responsibility for any errors or omissions in the articles as presented in this publication; nor are the concepts, ideas, procedures and opinions contained in these articles necessarily recommended or endorsed as valid by NYWEA, its board of directors, the editor, the executive director, or staff.

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♻ **Clear Waters** *is printed on recycled paper, using soy-based ink.*

President's Message | Winter 2013

Some are resistant to the winter months, but the right clothing and attitude can make it a lot of fun. With building snowmen, snowshoeing, skiing, snowmobiling, and crisp walks with loved ones – there is no end to the opportunities. So, enjoy!

Annual Winter Meeting 2014

Excitement builds as the winter meeting rapidly approaches. The theme, "Utilities of the Future," encompasses all aspects of how to better manage and harvest resources, including:

- Energy reduction through process efficiencies
- Energy production through the utilization of biogas, solar, wind and hydro
- Phosphorous recovery
- Biosolids reduction, reuse and resale
- Wastewater treatment effluent resale
- Asset management, and more

The program includes several technical sessions covering these topics, and much more. Don't miss the opening session, which will be educational, entertaining as well as action packed!

Important Note: Since Super Bowl XLVIII is on the weekend leading up to our meeting, crowds will be leaving the downtown area Sunday night and Monday morning. So please, build in extra time for inbound travel. To help accommodate, we scheduled the meeting one day later than usual, so that vendor set up is Monday, exhibits and technical sessions are Tuesday and Wednesday, and the awards banquet is Thursday.

Asset Management

This *Clear Waters* delves into asset management and planning. Optimizing processes, efficiencies and resources are a critical part of being a utility of the future. Managing and understanding these assets for both long- and short-term planning is equally as important. We extend a special "thank you" to Tim Taber for heading the Asset Management Task Force. The membership looks forward to hearing more as the work of this group unfolds. Not to be forgotten, we also thank Greg Lieberman for leading the Stormwater Task Force.

Additionally, I would like to thank the authors of this edition for their hard work and commitment, as well as the Publications Committee. We are particularly grateful for the extra time and assistance Dave Barnes gave in coordinating our excellent author submissions.

Scholarship Fund Program

Phase III of the scholarship fund is in full force. I'd like to thank the corporate sponsors and new donors who have already made contributions.

To briefly summarize, the scholarship fund has two parts: a matching fund, which is built by corporate sponsors at either the $2,500 level ($500/yr for five years) or the $5,000 level ($1,000/yr for five years); and secondly, donations from contributors who have never previously given to the scholarship fund. Each of these new contributors is encouraged to donate $100 ($20/yr for five years), which will go to the scholarship fund. For each $20 that a new contributor donates, an additional $20 is pulled from the matching fund, so the actual contribution is $40 a year over five years, or $200 in total.

To our corporate sponsors – we look forward to your help in building the matching fund! To our new contributors – please help make a difference for a young person who is interested in the environment. This is a small price and a great way to double your contribution!

Philippine Disaster

It seems like these natural disasters are occurring ever more frequently. As we continue to pick up the pieces from Sandy, the Philippines was recently crippled by the super typhoon, Haiyan. Please send your thoughts and prayers for the survivors, and if you would like to send donations, email the executive office (mah@nywea.org) for instructions.

Mark Koester

"Kindness is one of the greatest gifts you can bestow on another. If someone is in need, lend him/her a helping hand. Do not wait for a thank you. True kindness lies within the act of giving without the expectation of something in return."

– Unknown Author

Taking Stock of Your Assets

The first time I heard the term "asset management" used, was about ten years ago in a reference made by Phil Smith of the NYS Department of Environmental Conservation (NYSDEC) who was speaking about what the Village of Old Forge was doing to increase its efficiency and save money. A subsequent article on this was written in *Clear Waters* by G. Michael Coley (then with NYSDEC) and Ted Riehle, the former chief operator for the Village of Old Forge.

In its simplest terms, asset management practices are when a municipality takes stock of its assets, for example how many miles of pipe lie underground and what piece of machinery will be expected to wear out first. A good asset management plan is a roadmap to follow in identifying components of a municipality's largest capital investment that need to be dealt with as financial priorities. Then, members of a board, legislature or authority can make educated decisions and plan more efficiently for future expenses to maintain and/or replace important equipment.

Under the leadership of President Mark Koester, the New York Water Environment Association (NYWEA) created an Asset Management Task Force. Members of the task force are also serving as members of a newly created NYSDEC Wastewater Infrastructure Sub-committee, which is also looking closely at issues concerning asset management. As a result of their concerted efforts, much needed valuable information will be shared with NYWEA members, utility managers, municipal leaders and communities on how and why they can benefit from using this type of management planning.

During a recent Elected Officials Roundtable program in Victor, NY, an entire segment of the workshop was devoted to asset management. Information shared came mainly from the second edition of the publication, "Wastewater Management Handbook for Local Representatives" in which an entire chapter was devoted to the critical topic of asset management. This publication, produced in cooperation with the Environmental Finance Center at Syracuse University, is available on the NYWEA website. Rich in information, the 184-page resource guide is a useful tool not only for the newly-elected official, but for the seasoned wastewater treatment plant operator as well. A link to this document can be found on the NYWEA website.

Integrated Planning Program

On November 13, NYWEA co-hosted a workshop with the National Association of Clean Water Agencies (NACWA) on the subject of Integrated Planning. Over 40 key New York State stakeholders attended the meeting to discuss how best to apply the US Environmental Protection Agency's (USEPA) "Integrated Municipal Stormwater and Wastewater Planning Approach Framework." Participants found the meeting very constructive, and look forward to continued dialogue on the topic. The meeting addressed some of the challenges municipalities have as they address and work to meet regulatory mandates and requirements set forth in the Clean Water Act. The struggles of many communities stem primarily from strained resources as they relate to stomwater and wastewater mandates. Recognizing that these regulated communities need flexibility, the USEPA developed the useful Integrated Framework tool.

Left: Matthew Millea, (left), Deputy County Executive, Onondaga County and (right) Mike Garland, Director of Environmental Services, County of Monroe Department of Environmental Services at the November 13, Integrated Planning (IP) workshop in Albany.

Above: (l-r), Kathryn Garcia, Chief Operating Officer, NYCDEP; Carter Strickland, Commissioner, NYCDEP; and Adam Krantz, NACWA, during November workshop.

Above: Deborah Nagle, Director, Water Permits Division, Office of Wastewater Management, USEPA, speaks during November workshop.

In the future, NYWEA plans to take part in similar workshops or meetings and assist in making sure interested members are fully engaged and informed about this approach.

Connecting with Grassroots Organizations

Under the leadership of NYWEA's Dave Comerford, several members of the Utility Executives Committee met with key leaders associated with Audubon, Environmental Advocates and the League of Conservation Voters to discuss how the organizations can better communicate and collaborate on environmental policy issues. These meetings were initiated as a result of New York's Sewage Pollution Right to Know Act, signed into law in August 2012 (enacted on May 1, 2013), and how involvement and communication with NYWEA would have been particularly useful *prior* to this new law taking effect.

Get Involved in 2014

Please consider this *your* invitation to get involved with the New York Water Environment Association. We are continually looking for more member involvement in our activities, and you can check out our convenient online Committee Application form to do just that! By getting involved, you give back to your profession and, in turn, the rewards you'll receive I'm certain will be many. All my best wishes to our members and their families in the New Year!

Patricia Cerro-Reehil
pcr@nywea.org

With Bond On Your Team You Level The Playing Field With Regulators

It is increasingly difficult for municipalities to stay on top of all the new developments under the Clean Water Act. Wet weather flows, nutrient standards, sewage pollution right to know are just a few of the areas where new requirements are either proposed or newly adopted.

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- Application of DEC guidance memos (e.g., TOGs)
- Implementation of industrial pretreatment programs
- New and emerging program requirements (e.g., the Sewage Pollution Right to Know Act)

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- Permitting or enforcement actions
- Town/County districting, governance and financing issues
- Strategic counseling on addressing
  - wet weather flows
  - integrating comprehensive land use planning with sewer capacity needs
  - planning for impact of proposed rules (e.g., nutrient effluent limits; regulation of discharge of pharmaceutical residuals)
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Upcoming NYWEA Meetings & Chapter Training Sessions

Meetings & Chapter Training Sessions

Solids Handling and Dewatering
January 16, 2014, Williamsville, NY

86th Annual Meeting
New York City Marriott Marquis
February 4–6, 2014
(Please note: Tuesday–Thursday dates)

Confined Space Awareness
February 26, 2014, Bath, NY

Occupational Chemical Exposure
March 5, 2014, Binghamton, NY

Disinfection Optimization
April 3, 2014, Babylon, NY

Confined Space Awareness
April 8, 2014, Middletown, NY
April 18, 2014, Rexford, NY

Solids Handling and Dewatering
May 16, 2014, Rexford, NY

NYWEA Spring Technical Conference and Exhibition
June 2–4, 2014
Hyatt Regency, Hauppauge, NY

Disinfection Optimization
June 17, 2014, Hopewell Junction, NY

Occupational Chemical Exposure
July 17, 2014, Lockport, NY

Sequencing Batch Reactor Design and Operations
August 14, 2014, Lyons, NY
November 20, 2014, Babylon, NY

DMR: Proper Completion and Electronic Reporting
September 10, 2014, Watertown, NY
October 28, 2014, Monticello, NY

Solids Handling and Dewatering
October 23, 2014, Babylon, NY
October 29, 2014, Bath, NY
November 5, 2014, Syracuse, NY

Disinfection Optimization
November 13, 2014, Chautauqua, NY

Sequencing Batch Reactor Design and Operations
November 20, 2014, Babylon, NY

Water Views | Winter 2013

Sensible Plans for Managing Municipal Infrastructure

While talking with a high-level municipal official, I asked him about the community's strategy toward maintaining its clean water infrastructure. He replied, "We fix it when it breaks."

As we all know, that approach to infrastructure pretty much ensures that things will break – with resulting sewage spills, water outages, fines, bad press and the significantly heightened repair costs that come with an emergency response.

Plans to protect and maintain clean water infrastructure are generally referred to as "asset management plans." These plans can be used to facilitate: good financial management as infrastructure components need to be replaced; adequate maintenance to extend the life of infrastructure; energy efficiency improvements over the short and long term; and, storm and sea level rise resiliency upgrades implemented in a rational manner over a period of years.

Asset management plans can serve as a cornerstone of properly functioning wastewater treatment systems. Industry experts, regulators and wastewater operators generally seem to agree that asset management is a good idea. Such plans also allow managers to select which upgrades or repairs are the most important in the face of various statutory or permit requirements – useful information when working through issues with regulators and municipal budget agencies. These plans facilitate security and improved emergency response.

Wastewater infrastructure is the backbone of clean water, yet this infrastructure is often decaying. Because the public does not see it, there often seems to be an unwillingness to make sufficient investments to improve these facilities. Many argue that economic viability and growth depends on a sustainable public service infrastructure, including wastewater treatment. The information gleaned through good asset management programs can help make the case for sensible infrastructure investments.

As you will find out in this issue, asset management is the practice of managing infrastructure capital assets to minimize the total cost of owning and operating them while delivering the desired service levels. This practice incorporates detailed asset inventories, operation and maintenance tasks, and long-range financial planning. It puts clean water systems on the road to sustainability.

The New York State Department of Environmental Conservation has initiated stakeholder efforts to formulate an asset management strategy for municipal wastewater infrastructure. It will be useful to develop a policy that will define the essential elements of a successful asset management plan, as well as a means to effectively implement these plans. The asset management strategy will also review funding options to assist the municipalities.

Asset management is a win-win for the community, the state and the environment. Such plans allow communities to wisely target resources while protecting the environment. Statewide wastewater infrastructure asset management is overdue, and NYSDEC is eager to work with the New York Water Environment Association on making it a reality in New York State.

– James Tierney, Assistant Commissioner for Water Resources
NYS Department of Environmental Conservation

Focus on Safety | Winter 2013

Integrating Safety into Asset Management

As noted in this edition, asset management is a business process. While some entities may not yet apply it, this business focus allows more agility and flexibility than previously possible. The ultimate goal – the bottom line – is cost-effective resource control and decision-making. The asset management focus is on *strategic* decision-making, rather than on *tactical,* which is a major advantage. Why just fight today's fire when you can control the fuel?

For water system operators, the growing demands on system capabilities, limited human and physical assets, tax funding issues, and an often aging physical plant/infrastructure – all combine to significantly impact the ability to deliver on the mission of the organization. So just where does safety fit into asset management?

Injuries and safety hazards have a direct effect and impact on asset performance. When an employee is injured, the asset cannot function at its peak performance/service level. Few, if any, organizations have a list of fully-trained, technically superior substitute workers ready in the wings to step in. More often, another worker is assigned additional duties to cover for the injured co-worker. This means that now two systems possibly are not functioning at full or peak performance. In a risk assessment, this situation would be recognized as a potential hazard and performance gap that must be addressed. After identifying the situation and the gaps, the next step is how to correct the problem(s).

Mitigation plans help minimize the hazards/gaps for both the physical and human assets while providing a long-term path that supports the organization's mission. For safety concerns, this could include the establishment of: safety inspections of systems, accident investigation with corrective/preventive actions, current SOPs, lockout procedures, job safety analyses, chemical approval processes, regular training and safety schedules, full inspections and review of new/modified equipment, authorized employee listings (to limit hazardous activities to a select group), emergency drills (to identify areas of weakness), annual equipment inspections, a comprehensive safety manual, and a safety review of all capital improvements at the design phase. This, for a start!

After all this hard work is completed and it can be admired in those nice, shiny three-ring binders, the process is not yet complete. The hardest aspect to implement is what keeps the spark alive – establishing "the continuous improvement culture." This takes the right kind of leadership and the right kind of mindset at each layer of the organization. Unfortunately, it isn't in a binder on the shelf!

– Eileen M. Reynolds, Certified Safety Professional
Owner, Coracle Safety Management

Asset Management for Small Communities –
The Village of Weedsport Story

by Timothy Taber and James Saroodis

Asset management – it's a simple concept. Know your system's assets – equipment, pipes, machinery and supplies – so that service needs can be met at the lowest possible cost to the community. The difficult part for the owners of many small water and wastewater systems is implementing a plan for managing these assets, including their repair and replacement.

Of the more than 16,000 public wastewater systems in the United States, more than 70 percent serve 10,000 or fewer people. Many of these small systems have aged considerably, and major components of their systems are reaching the end of their useful life. For too many of those working for or with small wastewater systems, asset management may seem like a complicated and time consuming endeavor. While larger utilities have resources and tools that they can dedicate to asset management, smaller communities do not have the ability to dedicate staff completely to it, so asset management for them has to be a tool that assists them with their day-to-day work, without "getting in the way" of getting things done.

Courtesy of Village of Weedsport and Barton & Loguidice, PC

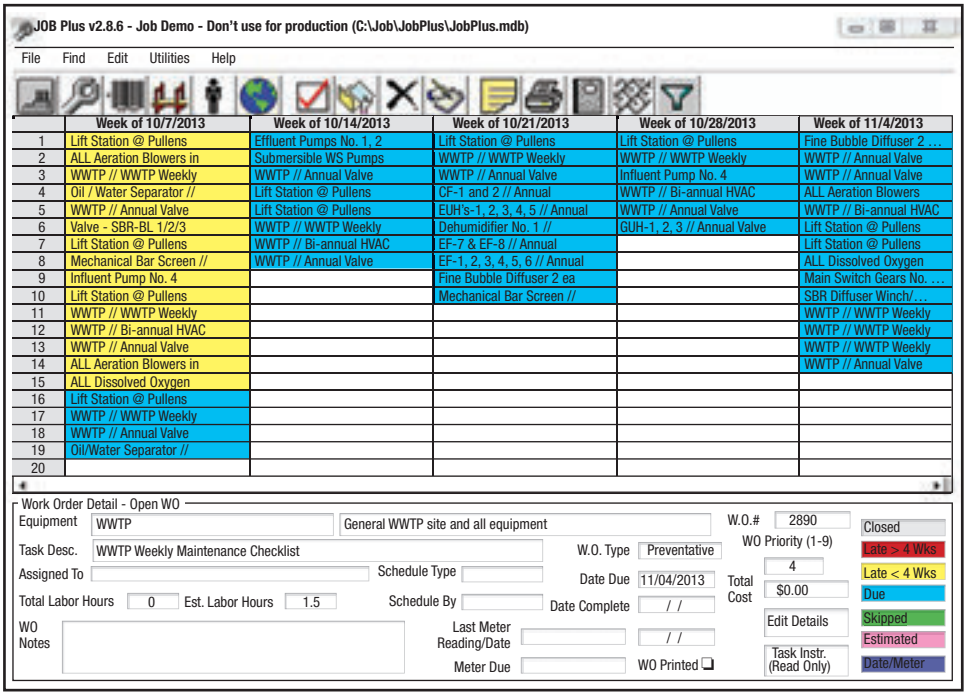
Village of Weedsport Wastewater Treatment Plant's sequencing batch reactors

Weedsport History

Weedsport, New York, is a small village in Cayuga County with a population of about 2,000. The wastewater treatment plant was originally constructed and placed into operation during the 1960s. By 2009, several of the major process components had reached the end of their life cycles and were in need of replacement. The village undertook a significant upgrade of the treatment plant in 2010, replacing most of the original equipment and tanks, and was fortunate to obtain financing from New York State Environmental Facilities Corporation (NYSEFC). The village mayor, board and Department of Public Works Superintendent were interested in maximizing the life and value of the community's investment (one of the largest in the village's history) and were looking for ways to be good stewards of these new assets. In 2011, the village decided to implement an asset management program with the assistance of Barton and Loguidice, PC (B&L) to protect the investment in the facility and prolong the life of the treatment plant's equipment. The goals of the asset management program were to:

- Create and maintain an electronic inventory of assets
- Identify critical assets using methodology supplied by USEPA resources
- Identify remaining useful life of all assets
- Implement a documented maintenance program with work orders that ensures assets receive inspections and maintenance to prolong equipment life or reduce the likelihood of failures
- Prioritize the allocation of resources, whether it is for capital improvements or in-house labor, with a risk-based arrangement
- Better capture costs associated with maintaining and repairing assets
- Establish a budget line and reserve accounts for replacing and rehabilitating assets
- Reduce paperwork and make smarter decisions
- Have a tool to capture information and history of assets to assist with succession planning

The asset management program for Weedsport was designed and implemented with the guidelines provided by the USEPA in its "Asset Management: A Best Practices Guide" publication which answered the five core questions of asset management:



(JOB Cat® Plus by Hach – a page example shown here)

Figure 1. CMMS software selected to track and schedule asset maintenance

1. What is the current state of the utility's assets?
2. What is the required level of service (LOS)?
3. Which assets are critical to sustained performance?
4. What are the best operation and maintenance (O&M) and capital investment plan (CIP) investment strategies?
5. What is the best long-term funding strategy?

What is the Current State of Assets?

To answer the first question, the village will keep an electronic, up-to-date inventory of its assets in a simple software tool. It was determined that the free software from the USEPA, the Check Up Program for Small Systems (CUPSS), was difficult to use for scheduling and tracking work – a key characteristic of the village's desired asset management program. Some research identified a low-cost software program that had the features and flexibility desired in managing the village's assets. Hach's JOB Cal® Plus software ***(Figure 1)*** was selected as a Computerized Maintenance Management Software (CMMS) solution capable of maintenance tracking and scheduling for drinking water and wastewater assets. The software proved to be easy to set up and use and it cost the village approximately $1,500.

After acquisition and installation of the software, it was decided that the information in ***Table 1*** would be collected and maintained on the village's assets:

Table 1. Information Collected and Maintained on Village Assets

Data	Description
Equipment ID	Unique identifier for each piece of equipment
Description	A brief description of each equipment item
Equipment Type	The type of piece of equipment
Location	The location (building and room) for each equipment item
Original Cost	The original cost of the equipment item. Since the treatment plant had recently being designed and constructed, much of the information was obtained from estimates from vendors provided during design or from payment requests from the contractor. Costs captured here were for both equipment purchase and installation and were useful for helping to forecast future asset replacement costs.

Courtesy of Village of Weedsport and Barton & Loguidice, PC

An example of the treatment plant's assets include these sequencing batch reactor blowers.

The JOB Cal software offers up to nine "user-defined" fields to fill in for each equipment item. In addition, the software allows value lists associated with these user-defined fields to be kept for more information. Configurations were made to the software to store the additional information for each equipment item, as shown in ***Table 2***.

Table 2. CMMS Software Fields

Data	Description	
Year Installed	The year that the equipment was purchased and installed	
Expected Life	The life expectancy of the piece of equipment before it needs to be replaced	
Consequence of Failure (CoF)	CoF was estimated as the degree of impact on the village's desired level of service should the asset fail. The real or hypothetical results were considered when selecting a value, including impacts on regulatory compliance, local government, customers and the community. The software was configured to have the following value list associated with this field:	
	CoF	**Value**
	Insignificant	2
	Minor	4
	Moderate	6
	Major	8
	Catastrophic	10
Equipment Condition	The current condition of each equipment item based on age and physical functionality (ranging from poor to excellent) was given this value list associated with this field:	
	Rating	
	Excellent	
	Good	
	Fair (Average)	
	Poor	
	Very Poor	
Redundancy	A value for the redundancy, which represents the functional redundancy of the equipment item, was also stored in the software. Values indicate what percentage of the equipment's functionality is duplicated by other equipment items.	
Equipment Vendor	The vendor or supplier of the equipment and information on where to obtain spare parts	
Equipment Manufacturer	The manufacturer of the equipment	

In addition to collecting information on the plant-based assets, prior GIS mapping of the collection system was used to capture similar information on all of the collection system assets (sewer lines and manholes) for the Village of Weedsport, and the data were stored in the CMMS software.

What is the Required Level of Service (LOS)?

Level of service (LOS) is the foundation of an asset management program. Village leaders recognized that by meeting or exceeding customer expectations, the utility would greatly improve its ability

continued on page 11

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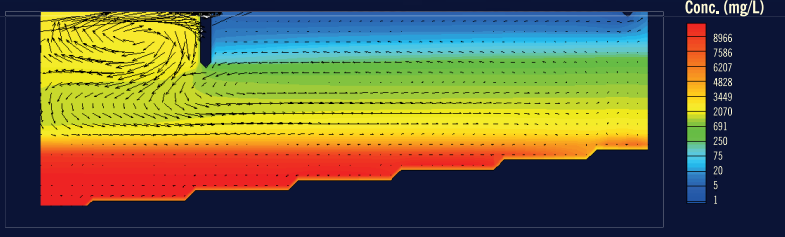

For one client, enlarging the center well and minor adjustment to the baffle improved a clarifier's performance enough to avoid having to construct an additional clarifier – a net savings of approximately $8 million.

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continued from page 9

to recover the full cost of doing business. A workshop was held in the village to develop very simple criteria for LOS, as shown in ***Table 3***.

Table 3. Asset Management Level of Service

Level of Service	Target
Employee health and safety	Zero injuries
Competitive rates/taxes	Within 5% of New York State average
Public image	No adverse media reports
Compliance with effluent discharge permits	100%

The LOS information was used in determining what the consequence of an asset failing would be (scored in the previous step); it also helped to identify which assets are most critical (or have the highest risk) to the village.

Which Assets are Critical to Sustained Performance?

Because all assets fail, it is important to understand the consequence of a failure and the likelihood that it is going to occur. Not every asset presents the same failure risk, is equally critical to the village's operations and meets the desired LOS. Therefore, it is important to know which assets are required to sustain the municipality's wastewater system performance. Critical assets are those that have a high risk of failing (old, poor condition, etc.) and major consequences if they do fail (major expense, system failure, safety concerns, etc.). The village decided how critical each asset is and ranked them accordingly.

To determine which assets are most critical to the sustained performance for the village, a risk-based scoring was used to rank the assets using probability and consequence of failure:

Risk Factor = Probability of Failure (PoF) x Consequence of Failure (CoF)

The consequence of failure scoring was rated on a 1 to 10 scale, as mentioned earlier. The probability of failure score was calculated as:

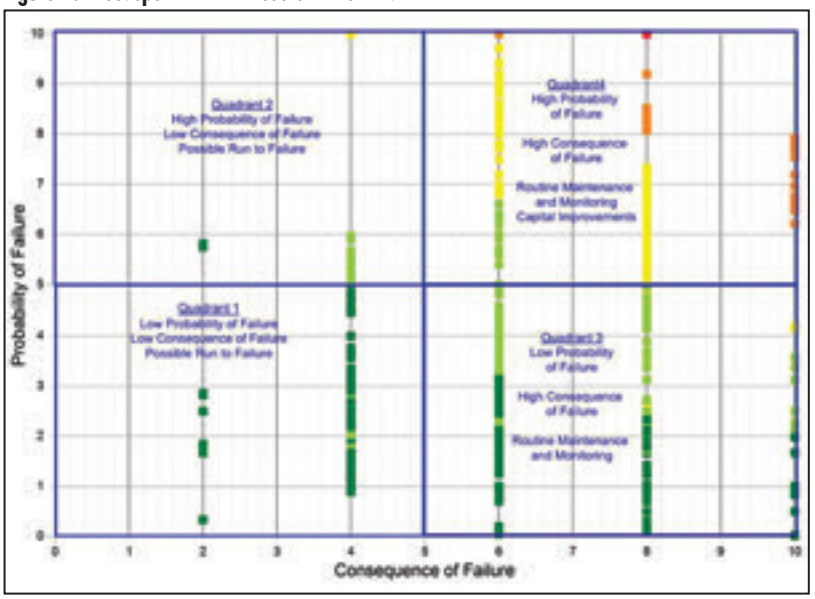
Probability of Failure = ([Estimated Useful Life – Remaining Useful Life]/Estimated Useful Life) × (1 – Redundancy) × 10

This also resulted in a score from 1 to 10. The redundancy factor used in the formula above was based on the percent redundancy associated with each asset, as derived from ***Table 4***.

Table 4. Redundancy Factor

Redundancy	Value Used in Equation
0%	0.00
50%	0.50
100%	0.90
200%	0.98

Figure 2. Weedsport WWTP Assets – Risk Matrix



Courtesy of Village of Weedsport and Barton & Loguidice, PC

While this determination of probability of failure is not perfect, as it is almost completely determined by the age of the asset and expected life of the asset, it does give a simple methodology for determining the likelihood that an asset can fail. In understanding the results of the scoring, the village can adjust the risk of assets by adjusting the expected useful life associated with each equipment item.

Based on the above risk scoring criteria, a "risk matrix" was established for all of the assets at the treatment plant, as well as a separate similar chart for the collection system. ***Figure 2*** displays how each asset scored on the risk matrix and the quadrants that were established to help determine the appropriate maintenance/management strategies that should be applied to each asset.

The results from this evaluation declares that most of the assets at the wastewater treatment plant scored with a very low overall risk to the village, as most of the assets were new or near new. Several assets that were not replaced or rehabilitated as part of the 2010 plant upgrade scored with a very high risk, as outlined in ***Table 5***.

As seen in ***Table 5***, the criteria used to determine the probability of failure is most influenced by the age and expected life of the asset, which causes older assets (which may be performing adequately) to have a high likelihood or probability of failure. The simple scoring criteria is acceptable as long as village leaders understand how the criteria were determined and are able to improve the scores to obtain reasonable results. The village makes it a practice to continually review the expected life it will obtain from each of its assets to help with keeping accurate probability of failure scoring, as well as to help build a capital improvement plan and determine suitable reserve budgets, as discussed next.

Table 5. Overall Risk

Equipment Number	Description	Year Installed	CoF	PoF	Risk
Influent Sluice Gate	Gate controls the flow to the headworks	1967	10-Catastrophic	10.0	100
Compost Blower	Compost Blower	1995	06-Moderate	10.0	60
Compost Spinner-Elevator	Compost Spinner-Elevator	1998	06-Moderate	7.5	45
Compost Conveyor	Compost Conveyor	1998	06-Moderate	7.5	45
Sludge Filter Press	Sludge Filter Press	2006	08-Major	3.9	31.1

continued on page 12

continued from page 11

Figure 3. Maintenance Procedure Form

Work Order 2846

Facility: Village of Weedsport ALL WWTP & WATER Facilities
Equipment: WWTP - General WWTP site and all equipment
Dept: WWTP-Support/MSC
Location: WWTP-Site
Task: Annual Valve Maintenance - Chlorine Contact Tank
Date Due: 10/14/2013
Assigned To:
Client:
WO Notes:

Date Complete:
WO Type: Preventative
Est Hrs: 1.5
Closing Meter:
Misc. Cost:

Labor:			Parts:		
Employee	Date	Hours	Item	Qty Required	Qty Used

Task Instructions:

1. Inspect ALL units for damage to paint or signs of corrosion.
2. Ensure all cable entry glands are secure and prevent water or dirt entry into actuators.
3. Check actuators to valve fixing bolts for tightness.
4. Ensure full understanding of process.
5. Verify safe to fully stroke the valves.
6. Cycle valves to either end of their full ranges.
7. Look and Listen for anything abnormal.
8. Ensure valves are moving freely or keep cycling.
9. Lubricate valves and actuators as required.
10. Ensure valves are left in appropriate location once completed.

What are Best O&M and CIP Investment Strategies?

The operation and maintenance (O&M) personnel and the capital budget account for an estimated 85 percent of a typical wastewater system's expenses. One of the goals of the village's asset management program was to optimize the work O&M crews are doing, where they are doing it and why.

Each equipment item was evaluated to determine what maintenance activity should be performed to prolong the life of the asset and reduce the likelihood that it was going to fail. Information from operations and maintenance manuals from the equipment manufacturers and vendors, advice from vendors and wastewater equipment service companies, and industry standard recommended maintenance guidelines were used in developing maintenance strategies.

As part of this work, detailed maintenance procedures and frequencies were established and loaded into the CMMS software. An example of a maintenance procedure is displayed in ***Figure 3***.

The detailed maintenance procedures and inspections continue to be a cornerstone of Weedsport's asset management program and have already saved the village tens of thousands of dollars by identifying and replacing equipment under warranty that is deteriorating or out of specification. The village has also benefited by identifying training and/or outside services to prolong the life of the assets at the treatment plant. For example, maintenance tasks recommended for the plant influent pumps were beyond the capabilities of the village's DPW staff; however, maintenance on them was necessary to help prolong their life and keep their performance at the required level. The village worked with a local service company to train its staff on the maintenance requirements so now the DPW staff is capable of keeping the pumps in good physical condition, reducing the likelihood that they will fail.

The DPW superintendent reviews the recommended maintenance procedures twice a week and assigns and prints work orders from the CMMS software. Staff members execute the work and record any comments and how much time and materials were used to perform the work. The history of all activities performed on each asset is recorded in JOB Cal and can be reported at any time.

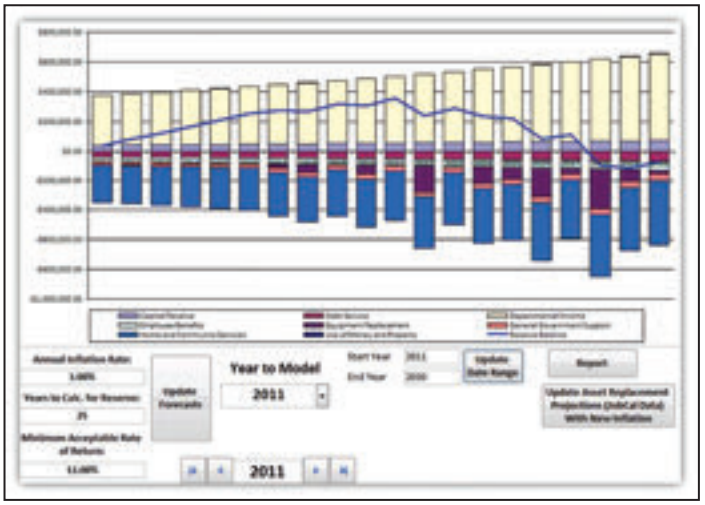
As the DPW staff is small and many of the members are responsible for maintenance of other village assets, the superintendent added other equipment items, including vehicles, parks, facilities, and more, into the software so they have a single tool that helps them plan and track all of their work with the assets.

Maintenance of the gravity sewer system is contracted out and a set budget is allocated each year for a contractor to pressure test and grout portions of the collection system. Originally, it took six to eight years for the contractor to cover the entire collection system, but each year the contractor is able to cover a larger percent of the system for the same cost, because of less grouting work to be done and the overall health of the collection system is improving. Currently, about 25 percent of the collection system is inspected, pressure tested, and grouted each year.

Image courtesy of Village of Weedsport and Barton & Loguidice, PC

Assets at the plant, like this pump, are maintained and serviced at regular intervals, and all work recorded on CMMS software.

Figure 4. Report Forecasting Equipment Replacement Costs



What is Best Long-Term Funding Strategy?

The mayor, village board, DPW superintendent, and treasurer understand that the village was fortunate to receive financing from the NYSEFC and benefitted from the American Recovery and Reinvestment Act for its 2010 plant upgrade. It is unlikely that the village will have an opportunity like that in the future. Weedsport is currently using the information in its asset management program to forecast future equipment rehabilitation and replacement costs and set aside reserve funds into an account to pay for upgrades

Custom reports were added to the software that analyze the data in the system to forecast equipment replacements and costs, rank them based on the asset risk score, and estimate how much the village should allocate to reserve funds each year to prepare for these expenses. The village runs the reports each year during the budget cycle, reviews the detailed data, adjusts any of the data (mostly expected life of the assets), and obtains a recommended amount to allocate to an equipment replacement reserve fund. This report is displayed in ***Figure 4***.

Results of the Program

The asset management program for Weedsport has been in place for two years and has already proved to be an extremely valuable tool. The program acquired a return on investment within one year, as the village had several assets replaced while under warranty (recommended asset inspections identified issues that may have not been identified before the warranties expired). The DPW staff continues to use the JOB Cal software to manage and maintain the assets and have come to rely on having information on the assets catalogued in a tool that is easy to use. In addition, the equipment history is being documented in a system that will be easy to continue when staff changes at the village, and will have all the details on the history of all the activities that have been performed on the assets.

Equipment reserve budgets are estimated using real data that is managed and updated on a frequent basis. The program and tools are used on a daily basis by the village to help municipal employees with their goals of being good stewards of their assets.

Because of the value the village has seen in its asset management program for its wastewater assets, there was a desire to include the water distribution system into the program. In 2013, the village, with the assistance of B&L, was able to obtain a mini grant from NYSEFC to map the water distribution system (water mains, hydrants and valves) and import the data into the CMMS software. The data was collected and loaded into the software in September 2013, and the village now has a single tool for the DPW to manage the village's water and wastewater assets, and the capability to add every village-owned asset into the system, many of which have already been added.

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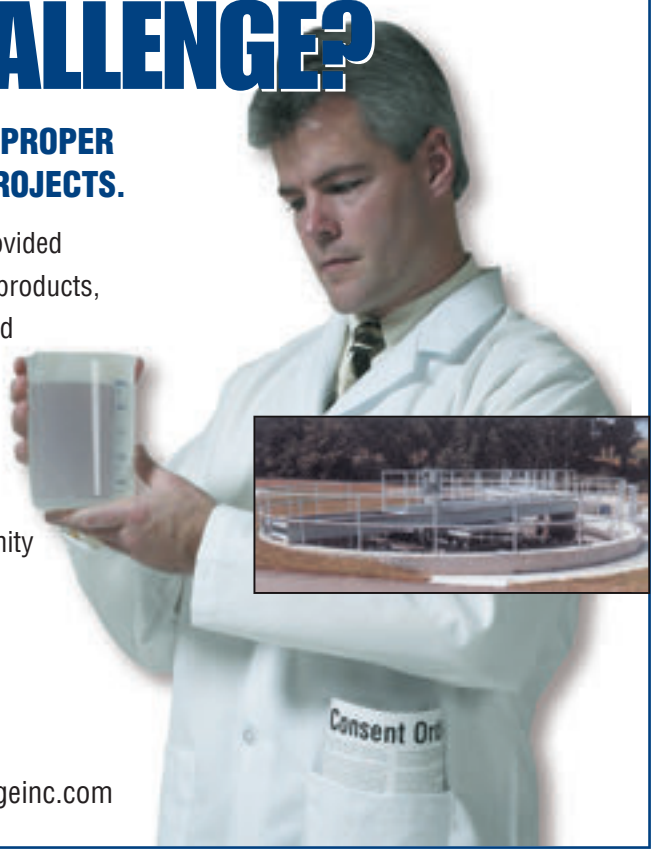

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NYCDEP's Asset Management Program Improvements

by Jason J. Galea and Celine Hyer

The New York City Department of Environmental Protection (NYCDEP) is one of the largest utilities in the United States, providing water and wastewater service to more than nine million customers in the city and surrounding upstate suburbs. The NYCDEP manages New York City's water supply, providing more than one billion gallons of water each day. The water is delivered from a watershed that extends more than 125 miles from the city, comprising 19 reservoirs and three controlled lakes. Approximately 7,000 miles of water mains, tunnels and aqueducts bring water to homes and businesses throughout the five boroughs, and 7,500 miles of sewer lines and 96 pump stations take wastewater to 14 in-city treatment plants. The agency has nearly 6,000 employees, including almost 1,000 who manage the upstate watershed.

For the past six years, NYCDEP has been proactive in implementing an overall asset management program, including performing a condition and criticality (consequence of failure) analysis of its assets to prioritize the capital state of repair (rehabilitation and replacement) projects. The project began in July 2009 for the vertical assets (plants, pump stations, bridges, dams, roadways, reservoirs and buildings), and in May 2011 for the linear assets (water, sewer and stormwater pipelines). The vertical assets assessment was completed in April 2013. Outcomes from the project included a prioritized four- and 10-year capital improvement program for the vertical assets as well as a custom asset information system that stores the prioritization data and project information. For the linear assets, the prioritized financial needs by pipe class were determined, using descriptive statistics and the KANEW model (an R&R planning tool developed by the Water Research Foundation) for the next 50 years for sewer, water and stormwater distribution and collection piping systems.

Vertical Asset Program Improvements

The first phase of the asset management program included field and desktop condition and criticality assessment of all NYCDEP's water and wastewater treatment assets. The facilities evaluated included water shafts, dams, bridges, wastewater treatment plants and support facilities. In addition, the project developed an asset management information system tool to store all of the information, support capital project prioritization and create management reports. Prior to beginning any of the assessments, collaborative workshops were held to establish the methodology for physical and performance condition, criticality and scoring. Because of the size of the NYC water and wastewater system, there are three operating bureaus: the Bureau of Wastewater Treatment, which operates and maintains all of the large diameter interceptors, wastewater pumping stations and 14 treatment plants; the Bureau of Water Supply, the water system north of the Hillview Reservoir, which consists mostly of reservoirs and tunnels; and, the Bureau of Water Supply and Sewer Operations, which comprises the wastewater collection and water supply systems south of Hillview Reservoir.

Guideline documents were created for each of these operating bureaus that describe in detail how to perform the field physical condition assessments as well as how to score the asset criticality and performance through a combination of interviews and document reviews.

Vertical Asset Assessment Methodology

The project prioritized the vertical assets for consideration in the Capital Improvement Program utilizing the following equation developed by the International Infrastructure Management Manual, written by NAMS (New Zealand Asset Management Support).

ASSET PRIORITY = (Physical Condition + Performance Condition) * Criticality

To capture the full breadth of asset information, condition was defined to consist of two scores – physical condition and performance condition, that are added together to comprise the overall asset condition score. The physical condition represents the current physical state of the asset and was completed through a field visual inspection, in most instances. For a small portion of the assets where current asset data was known, a desktop assessment utilizing existing inspection data and/or staff knowledge was completed. The performance condition represents current and future operational capabilities of the equipment related to efficiency and the level of service the asset is required to perform. It is completed through analysis of operations and maintenance (O&M) data, inspection observations, O&M interviews and document reviews, including Computerized Maintenance Management (CMMS) reports, regulatory reports and design plans. Specific scoring criteria and weightings were based on industry best practices.

Table 1 shows the scoring and definitions established for performance condition for one of the bureaus.

continued on page 16

Courtesy of Wards Island WWTP

Wards Island WWTP serves over one million people living in upper east Manhattan and in western Bronx.

continued from page 15

Table 1. Performance Condition Criteria

DEP Criteria	Assessment Level	Adjusted Weight	Condition on Measure	1 (excellent)	2 (good)	3 (moderate)	4 (poor)	5 (very poor)
Capacity	Process	25%	Ability to meet current capacity	Average Yes* Peak – Yes*	Average Yes* Peak – Yes**	Average Yes* Peak – No**	Average Yes** Peak – No**	Average No** Peak – No**
			Ability to meet future capacity	Average Yes* Peak – Yes*	Average Yes* Peak – No*	Average Yes** Peak – No**	Average No* Peak – No**	Average No** Peak – No**
Regulatory	Process	20%	Ability to meet current regulations & utility goals	Yes	Yes	Yes	Yes, with some modifications req'd	No
			Ability to meet future regulations & utility goals	Yes	Yes, with some modifications req'd	No	No	No
Reliability	Group	30%	Average time equipment is available when needed	99–100%	95–99%	90–94%	85–89%	< 84%
O&M Issues	Group	15%	Frequency of O&M issues (excluding breakdowns)	None	Very frequently, *Quarterly*	Infrequently *Monthly*	Frequently *Weekly*	Very frequently *Daily*
Obsolescence	Group	10%	Status of equipment technology	Technology best available/state of the art	Technology industry standard/ Tried & True	Technology considered appropriate	Technology nearing obsolescence	Technology obsolete/out of date

**With one unit out of service* ***With all units in service*

Table 2. Mechanical Asset Physical Criteria

Criteria	Weighting Percent	Condition	1	2	3	4	5
CORE ASSESSMENT							
Corrosion	20%	Surface only	0%	<10%	10%–50%	>50%–75%	>75%
		Structural	None	None	None	1 location	>1 loc
Leakage	30%	Gaskets/Connections	None	Historic only	Drip only	Stream 1 loc	Stream >1 loc
		Holes/Failures	None	None	None	1 loc	>1 loc
Concrete Pedestal or Steel Supports	15%	Surface cracking/Loose grout	None	10%	10%–50%	>50%–75%	>75%
		Through cracks	None	None	None	<25%	>=25%
		Missing pieces	None	None	None	None	1 or more
		Surface corrosion	None	<10%	10%–50%	50%–75%	>75%
		Structural corrosion	None	None	None	<25%	>=25%
		Missing/Broken anchors	None	None	None	<25%	>=25%
ANCILLARY ITEMS							
Piping/Valves	15%	Leaks, gaskets	None	None	Drips only	Stream 1 loc	Stream >1 loc
		Leaks, holes/failures	None	None	None	1 loc	>1 loc
		Corrosion, surface	None	<10%	10%–50%	>50%–75%	>75%
		Corrosion, structural	None	None	None	<20%	>=20%
		Support damage	None	None	None	<20%	>=20%
Local Panels	5%	Surface corrosion	None	<10%	10%–50%	>50%–75%	>75%
		Structural damage	None	None	None	1 loc	>1 loc
		Internal corrosion, leakage	None	None	None	Yes	Yes
		Panel instruments, non-function	None	None	None	<20%	>=20%
Field Instruments	5%	Damage/non-functional devices	None	None	None	<20%	>=20%
		Leakage	None	None	Drips only	Stream 1 loc	Stream >1 loc
Electrical Connections	10%	Conduit/J. Box surface corrosion	None	None	<20%	>20%–50%	>50%
		Damage/gaps/missing gaskets	None	None	None	1 loc	>1 loc
		Exposed wiring	None	None	None	1 loc	>1 loc

Physical condition was also defined on a similar 1 to 5 scale. Engineers inspected assets visually in the field utilizing different criteria dependent on the type of asset, for example, whether the asset was mechanical, electrical, HVAC, and structural (both structural process asset and building structural assets). The standard performance and physical condition criteria and scoring definitions achieved two goals, consistency among the multiple assessors and a repeatable process for future evaluations.

Table 2 shows examples of a mechanical asset condition scoring criteria.

As important as the physical condition of an asset, understanding the criticality of an asset is equally important to determine the relative priority of repair or replacement. Asset criticality is defined as the consequence of asset failure. Different assets have different consequences depending on a number of characteristics, including asset location, safety, customers served, redundancy, regulatory compliance and cost/time to repair. For vertical assets, the consequence of failure was based upon a weighted set of criteria that covers the social, financial and environmental impacts. To incorporate redundancy, e.g., that there is spare installed equipment or back-up power available in all operating conditions, the assets were evaluated at the group level. Criticality scores include an assessment of the overall system context, design criteria and performance goals, review of applicable documents, including permits, regulatory correspondence, master plans, facility drawings, repair cost history and interviews with appropriate management and operations staff. The general scoring definitions for one of the bureaus is shown in ***Table 3***.

Asset scores were determined based on the physical, performance, and criticality scores. Depending on the asset scores, assets were assigned into an asset group. This, in turn, would start the process of developing a subproject. Several subprojects would be combined to develop a project. Projects then are ranked and prioritized for placement in the capital improvement program. The score ranges and definitions are identified in ***Table 4***.

Some additional business rules were also established to allow for a more in-depth analysis of the individual physical, performance and criticality criteria asset scores to ensure that assets near the top of any range were reviewed for inclusion in a repair and replacement program. Using the asset scores to start the process of developing capital projects allowed for a simple and transparent process in creating the four- and 10-year budgets.

Asset Management Information System Tool

An Asset Management Information System (AMIS) computer tool was developed for this project to standardize the asset condition data collection, QA/QC, analysis and reporting across all NYCDEP facilities to support effective capital planning.

Key functionality includes:

- Storage and retrieval of asset data for physical condition, performance condition and criticality (consequence of failure)
- Analytical tools to perform overall prioritization assessment following asset management best practices for incorporation of field condition assessment data, asset performance data and asset criticality ratings
- Analytical tools to bundle assets together and create sub-projects and larger capital projects for project prioritization
- Prioritization of asset rehabilitation and replacement (R&R) needs at all NYCDEP facilities by location, asset class or asset type through business cases

continued on page 19

Table 3. General Scoring Definitions

Criteria	Weight	Scoring	Scoring Evaluation Description
Regulatory Compliance	20%	1	No Impact
		2	Minor noncompliance event and/or localized environmental impact that may be publicized
		3	State/Federal noncompliance event and/or widespread environmental impact that is highly publicized
Level of Service	20%	1	No Impact
		2	Localized customer outages or impacts
		3	Widespread customer outages or impacts
Hazard Potential	30%	1	No Impact
		2	Failure creates potential for injury to public (localized customers) or NYCDEP staff
		3	Failure creates potential for injury to public (systemwide customers)or NYCDEP staff fatality
Financial (O&M) Impacts	15%	1	No Impact
		2	Moderate O&M Cost/ Effort to repair
		3	Large O&M Cost/ Effort to repair
Redundancy	15%	1	Complete redundancy for all operating conditions and backup power
		2	Limited redundancy (e.g., for average but not peak conditions) and connection for backup power
		3	No redundancy or back-up power

Table 4. Project Group Score Ranges & Definitions

Asset Score Group	Asset Score Range	Guidance
Group 5	24 to 30 Low Bound: 4+4*3=24	• Highest consequence assets in poor condition • Consider for year 1-2 of the CIP
Group 4	15 to 23.99 Low Bound: 3+3*2.5=15	• Moderate consequence in poor condition to high consequence in fair condition • Consider for year 2-4 of the CIP
Group 3	10 to 14.99 Low Bound: 4+4*1=8	• Low consequence in poor condition to moderate consequence in fair condition • Consider for future 10 year CIP
Group 2	4 to 9.99 Low Bound: 2+2*1=4	• Not under consideration for CIP at this time, unless bundled with related project
Group 1	Less than 4	• Not required for CIP consideration

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continued from page 17

- Development and scheduling of capital projects required for asset R&R planning, including financial analyses for asset base cost, engineering, installation, construction, inflation and contingency

The AMIS also provides centralized storage via a relational database and secure web- based access for system configuration, data entry and reporting by NYCDEP staff. Application level security is provided for roles-based user access outputs from the database, including field inspection sheets for physical condition scoring, business case templates for capital project prioritization and summary level graphs showing results of the physical, performance and criticality assessments by facility, process or other asset hierarchy level. The business case templates store the information that is used to assign a prioritization score to each project that is comprised of bundled assets of similar asset level priority scores across a facility or like group of assets. Nine scoring elements are used to create a weighted score for each proposed project to determine its overall priority. The criteria and NYCDEP-specific weights are presented in ***Table 5***.

Table 5. CIP Prioritization Criteria

Category	Criteria	Weighting
1	Physical Condition	14%
2	Performance/Process Condition	16%
3	Regulatory/Environmental	16%
4	Service Level/Reliability	12%
5	O&M and Hazard	12%
6	Growth/Public/Community	7%
7	Public Image	8%
8	Financial	8%
9	Efficiency/Energy	7%

Linear Asset Program Improvements

The second phase of the asset management improvement involved the linear assets, including the wastewater collection (sanitary and combined), stormwater and water distribution utility pipes for the five New York City boroughs. The project design included the development of long-term annual investment levels to maintain reliability and level of service. Unlike the vertical asset phase of the project, the linear asset piece focused on the probability of failure among classes of pipes rather than individuals pipes. The implementation of the KANEW financial forecasting model provided the capability to perform "what if" scenarios to evaluate different investment levels versus expected performance to balance and optimize the overall investment. To develop inputs for the KANEW model, the project established service levels, performed a consequence of failure analysis, and a condition (probability of failure) analysis and scored pipes.

Courtesy of North River WWTP

New York's North River Wastewater Treatment Plant, the only such facility with a public park built on top

Assessment Methodology

Utilizing existing data and the American Water Works Association (AWWA) benchmarking report, service level targets were developed ***(Table 6)***.

Table 6. Service Levels

Utility	Service Level (SL)	SL Measure
Water	Reliability (Break Rate)	Breaks/100 miles/year
Sanitary	Efficiency (Work Order Rate)	WOs/100 miles/year
Stormwater	Efficiency (Work Order Rate)	WOs/100 miles/year

Asset condition and effective useful life were evaluated for each utility consistent with the data available from the NYCDEP work order system for comparison to the service level targets. The evaluation utilized a combination of regression and graphical analysis techniques. In addition, the water pipe evaluation also utilized the Linear Extended Yule Process failure forecasting model which provides a probability of failure score. To account for main replacements and breaks not captured in the work order system, manual adjustments were made.

Condition ratings were assigned to pipes in each utility based on performance versus the current system average service level. Where data were insufficient for a type of pipe, interpolation from results for similar pipes was used. Condition scoring across all utilities was normalized using a 1 to 5 scale, which is consistent with accepted practices for sewer pipe condition grading and similar to the vertical asset scoring. For water pipes, the final analysis was broken down by major pipe material, including cast iron, ductile iron and steel, since each exhibited significantly different behaviors.

Similar to the vertical assets, a consequence of failure (CoF) evaluation followed established asset management best practices for "triple bottom line," which considers the economic, social and environmental impacts of a failure. The consequence of failure score of 1 to 3 was applied to each of the criteria from lowest to highest. The highest score governed the final CoF rating. The project team utilized GIS queries to score individual pipes based on the attributes of the pipe, the consequence of failure and the estimated useful life of the entire class of pipe.

The vertical and linear asset management program systemizes the development of the capital repair and replacement program and ensures a transparent process for investment in water and sewer infrastructure. The NYCDEP has a robust capital program, with a planned $14 billion in investments over the next 10 years that will create up to 3,000 construction-related jobs per year.

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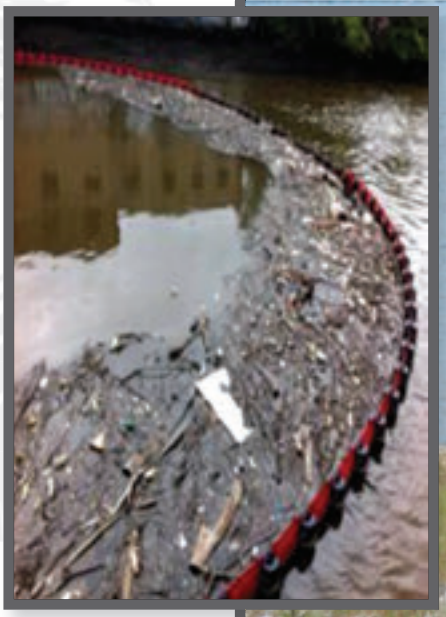

Above: Bronx River containment site

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Long-Term Funding and Credit Analysis: A Finance Industry Perspective

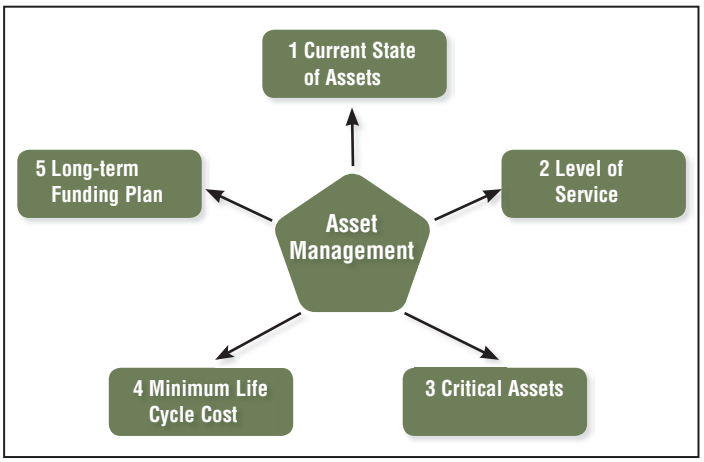
by Eva D. Rippeteau and Andrew DeStefano

Municipal water and sewer utilities are fee-based, long-term monopolies that provide highly essential services to the general public. Provision of these services is generally carried out by local governmental entities, but heavily regulated by state and federal environmental and public health agencies. The regulators impose and monitor compliance with strict laws, guidelines and standards for distributing safe drinking water and properly treating and disposing of wastewater. Given their size and criticality, utilities are highly capital intensive with many interrelated systems and facilities requiring constant renewal and replacement, along with infrastructure investment, to meet a host of environmental and other regulations. Targeted and general capital improvements are best implemented when a utility has a comprehensive and current asset management program and can plan projects in order to minimize system failures and maintain uninterrupted service.

The United States Environmental Protection Agency (USEPA) lists "long-term funding" as a part of its five requirements for effective asset management ***(Figure 1)***. This is because not all capital improvements can be financed with internal resources alone, and managers and operators who are familiar with a utility's assets can more accurately predict and plan capital needs, formulate an accurate budget, and modify customer rates and external borrowing as needed for short- and long-term financing for a budget. Asset management also enables a utility to address various system capital needs in order of severity and practicality and possibly execute them in tandem with adjacent or similar needs, or even in conjunction with other municipal departments.

This article explains how asset management influences a utility's long-term planning process, impacting financial and operational stability and overall system credit quality. Following a review of available funding options, asset management is explained, both in concept and implementation, for how it effectively underpins many of the major rating criteria employed at Fitch Ratings.

Figure 1. USEPA's Five Requirements for Effective Asset Management



Fitch Ratings considers each of these five core questions during its review of the credit strengths of water and sewer utilities that issue debt in the public bond markets. *Source: Asset Management: Best Practices Guide (2008),USEPA Office of Water, accessed www.water.epa.gov.*

Funding Types and Methods

An important role that utility managers and their governing boards play is in the prediction of planning for capital needs that will allow their utilities to provide continuous high quality services and meet the needs of their service territories in the most cost-effective manner, both today and in the future. Most utilities are considered enterprises of their respective governmental service areas and, therefore, are expected to recover the cost of operations and capital programs through user fees. Operational expenses include mandatory payments critical to the function of providing services, such as salaries, electricity and chemicals; and, therefore, these expenses are always paid for first. Remaining cash is then available for other purposes, including debt payments, if applicable, and to fund capital programs.

The ability to internally fund capital projects will depend on a utility's rate structure and the size of its capital improvement plan (CIP). Standard methods for funding capital programs include existing cash generated from revenues and excess historical operations, future excess cash flows, and leverage (bonds and loans). These funding sources are not mutually exclusive, as most utilities employ a combination of all of these given the scope of their capital needs and the amount of existing resources on hand. Larger projects may warrant the issuance of a substantial amount of debt, as this will provide necessary upfront capital funding, and then allow the utility to match long-term debt repayment with the useful life of the assets to be constructed. Systems with smaller capital plans may opt to fund ongoing projects from available internal resources or cash, if sufficiently available.

A common approach for smaller utilities with little or no bond market access is to participate in their respective statewide Drinking Water or Clean Water State Revolving Funds (SRFs) initiated by the USEPA. These programs function as shared-risk loan pools partially funded by state and federal grants to provide low interest loans to qualified systems in need of funding for necessary capital projects. Though funding is extended to every qualified applicant in a given state, the SRF program serves as an important resource for small or disadvantaged communities that may demonstrate a lower capacity to repay debt.

Other forms of borrowing include private bank placements, short-term bonds and loans, lines of credit, revolving bank loans and short-term commercial paper, among others. However, the most predominant, publicly disclosed funding mechanism in the United States for utilities is long-term borrowing, typically in the form of a publicly offered debt issuance or bond. As of the second quarter of fiscal 2013, the amount of outstanding municipal debt was reported to be about $3.7 trillion.[1] This market is supported by investors who in large measure depend on the independent assessments of credit quality, or ratings, most commonly provided by credit rating agencies such as Fitch Ratings (Fitch).

Ratings Criteria

Fitch relies on several key attributes to assign long-term bond ratings that inform the investment community ***(Figure 2)***. The first

continued on page 23

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continued from page 21

is an assessment of a utility's governance and management team. The level of tenure, years of experience, and political autonomy of influential managers are important indicators of their familiarity with the utility and its vital functions. The policies and procedures employed by management demonstrate its priorities and the degree to which it plans for the present and the future. Financial forecasting and asset management policies demonstrate a willingness to seek cost-effective and reasonable financial and capital plans.

Figure 2. Fitch's Water & Sewer
Rating Criteria
Governance and Management
• Leadership
• Policies and Forecasts
• Political Impartiality
Operations
• Customers and Service Area
• Water and Sewer System Operating Statistics
• Regulatory Compliance and Climate
Debt and Capital
• Capital Improvement Plan
• Funding Sources
• Leverage and Debt Structure
• Legal Bond Covenants
Financial
• Billing and Collections
• Rates and Charges
• Audited Financial Trends and Performance
• Stress Test Performance

Utility managers with an extensive inventory of the system's assets and their lifespan can more accurately predict the most pressing and sustaining capital needs, budget accordingly, and execute projects on time. They will also know when and by how much they should raise utility charges, if necessary, to fund these projects, and at what level price elasticity becomes a concern. In addition, they will have the ability to navigate the relevant rate approval boards and political actors in order to enact the necessary rate increases in a timely fashion.

A well-run system typically demonstrates strategic management practices that will take into consideration the economic climate and cost of service to ratepayers, the system's long-term capital and resource needs, and the various financing mechanisms available to meet those needs. The effectiveness of a utility's governance and management structure overarches the remaining attributes, as important decisions made at the top will influence operational, financial and debt-related consequences throughout the rest of the organization.

The next attribute is the quality of a utility's operational profile. This includes the level of long-term supply, compliance with regulatory bodies, capacity to serve current and future expected customers, and the overall quality of that service. Asset management is imperative to the success for all of the above. To effectively serve its customers, a utility must know the condition of its assets, and how and where to fix them so that service is uninterrupted. The latter is preferably done without imposing rate shock (sudden and large rate increases) on the customer.

There are many operational issues that can be avoided or mitigated through system-wide asset management. For instance, if distribution and conveyance pipes are leaking, revenue might be forgone and environmental laws broken. However, asset management can identify operational risks early, lowering the costs through upfront repair versus the potential hazard of deferred capital maintenance, and the possible regulatory issues that might ensue.

As mentioned, some utilities opt to acquire external financing in order to fund their capital programs. This approach can take several forms and often varies based on market interest rates and a utility's ability to garner interest in the public debt markets. The third attribute considered by Fitch analyzes a utility's debt and capital profile, focusing on the composition of debt, the motive for issuing, and the burden it may impose on the rate-paying base. The size of a customer base, both in the present and as predicted in the long term, is important to understanding the ability of that base to generate revenues sufficient to service any debt. Fitch assesses leverage ratios relative to per-capita and customer costs, as well as

continued on page 25

Photo by Eva Ripperteau

The NYC Department of Environmental Protection spent $5 billion to upgrade its largest wastewater treatment plant, Newtown Creek, which has 310 mgd treatment capacity (this shows a section of the plant's iconic egg-shaped digesters). Long-term bond issuances were acquired by NYCDEP's financing arm, the NYC Water Finance Authority, to finance this, among other major projects.

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continued from page 23

total debt outstanding in relation to the size of the system's capital base.

Also important are the legal bond covenants that dictate the terms of repayment. For example, the extent to which covenants require a utility to maintain a financial cushion or contingency of net revenues above its level of debt payments may promote long-term financial stability and a greater likelihood of debt repayment. In addition, it is crucial to know which revenues – recurring versus one-time payments – are pledged for bond repayment, as this will determine the volatility of the utility's revenue stream and, therefore, its reliability for annual debt payments.

A final attribute in assessing credit quality is the utility's financial profile, the importance of which has been alluded to in the themes already discussed. As mentioned, asset management assists in long-term spending and rate expectations on behalf of the governing body, regulators, and customers. Financial projections and CIPs informed by a comprehensive inventory of the state-of-repair of the system are more likely to be realized. Moreover, utilities able to propose projects that have a realistic expectation of being executed within their budgeted year can also more concretely justify future funding needs to their governing body.

Sound financial projections will indicate whether the utility will have to raise customer rates or acquire external funding sources, or both, to meet capital funding needs. In the event of raising rates, the utility must consider whether or not the increases will exceed the majority of its customer base's ability to pay, i.e., whether charges are affordable given median household income and the poverty rate. Fitch views favorably a utility that includes a percentage of fixed costs in order to maintain a level of acceptable income despite potential volumetric fluctuation during times of decreasing consumption. Taking all of this into consideration, a well-reasoned and supported financial plan will better position management to attain political support for rate-setting plans.

From a credit perspective, the strong fundamentals of municipal water and sewer utilities – their essential service provision and general ability to set rates to increase revenue – have produced favorable financial margins and strong protections for bondholders. However, every issuer is different and nuanced. The credit analysis of a debt issuer must be quantitative: assessing leverage, capital, financial trends and decisions; as well as qualitative: understanding the managerial, operational, regulatory, political and idiosyncratic challenges a utility faces. These important and holistic considerations will factor into a utility's ultimate ability to run efficiently and repay debt. Asset management, whether in the financial, physical, or governance sense, helps facilitate all of the above, resulting in greater efficiency, more reliable service, and potentially lower costs over time.

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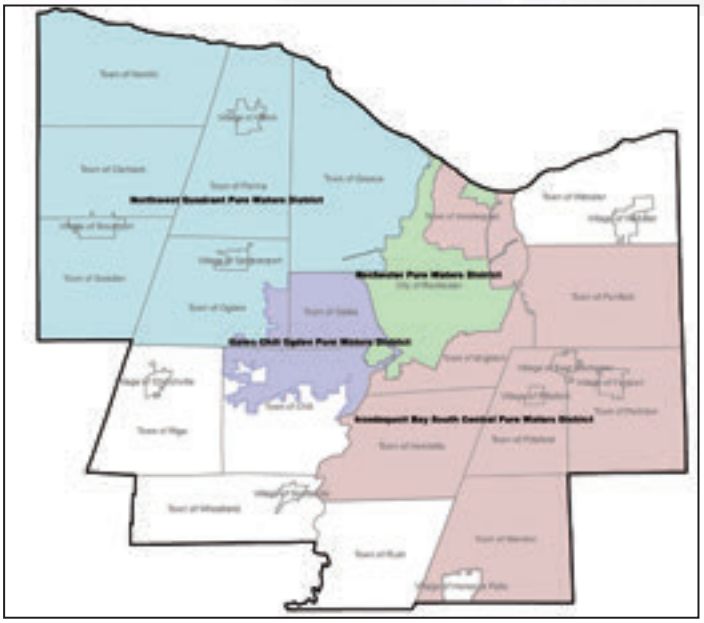
Reference

1. Lisa Lambert, "Shaken US municipal bond market contracted in second quarter," 9-25-13, http://www.reuters.com/article/2013/09/25/us-usa-economy-debt-municipals-idUSBRE98O19P20130925.

Monroe County Department of Environmental Services Pure Waters District-Wide I/I Master Plan

by David Cross, William Putt, David Barnes and Mike Miller

Monroe County in New York State has a population of more than 730,000 residents. The Monroe County Department of Environmental Services (MCDES), Division of Pure Waters, is responsible for providing combined storm and sanitary collection and treatment to the City of Rochester and sanitary collection for surrounding communities. Formed in the late 1960s, Pure Waters consists of four districts which include the Northwest Quadrant (NWQ) District, Gates-Chili-Ogden (GCO) District, the Irondequoit Bay-South Central (IBSC) District and the Rochester District. The collection system consists of approximately 1,200 miles of surface collector sewers, 110 miles of regional surface interceptors, 30 miles of Combined Sewer Overflow Abatement Program (CSOAP) deep rock tunnels and 60 remote pumping stations. Wastewater is treated by two regional wastewater treatment plants (WWTPs) – the Northwest Quadrant WWTP and Frank E. Van Lare WWTP. In general, the GCO, IBSC and Rochester districts are tributary to the Frank E. Van Lare WWTP located in the northern section of the Town of Irondequoit, while the NWQ District is tributary to the Northwest Quadrant WWTP in the northern section of the Town of Greece. The effluent from both WWTPs is discharged to Lake Ontario.



Courtesy of MCDES

Map of the Monroe County Department of Environmental Services Pure Water Districts

As with most wastewater utilities, the community systems vary in age and materials of construction. A common issue with aging sewerage infrastructure is infiltration of groundwater and inflow of stormwater into the sewer pipes via defects and deterioration of the aging facilities. Advanced age brings challenges, particularly when financial resources available for operation and maintenance are limited more now than ever. Rainfall derived infiltration and inflow (RDII) presents a never ending challenge to collection system owners in maintaining wastewater infrastructure operations. The more problematic impacts of RDII control for MCDES are excessive levels of wet weather flows that cause sewer surcharging in several localized areas throughout the collection system. Surges in flow to the Northwest Quadrant WWTP can also impact operations and performance of the treatment processes. The RDII has not reached levels where frequent or regular instances of sewer backups or sanitary sewer overflows occur or the ability to comply with regulatory discharge permits has been compromised. It is apparent that RDII does, and will continue to, adversely affect the structural integrity of infrastructure and reduce available sewer system reserved capacity for future growth and development. The MCDES does not currently have any regulatory enforcement pressure to perform this work, however, the county is being proactive in addressing the issues.

Master Plan Prepared

As a component of the overall mission of cost-effective stewardship of infrastructure, protection of public health and of the local water environment, a Pure Waters District-Wide Infiltration and Inflow (I/I) Master Plan was prepared to guide future efforts to control the effects of RDII. Pure Waters owns and operates the interceptors and trunk sewers, however, the communities own and operate the majority of the tributary collection systems. The project will identify the sources of RDII and work together with the communities to develop cost-effective solutions. The goal of the Master Plan is to identify and implement high benefit to cost ratio system renewal and rehabilitation work to minimize the adverse impacts of RDII and maintain an acceptable level of service for the wastewater collection and treatment system infrastructure.

The initial phase of work included a preliminary assessment effort that involved compiling and reviewing available information on prior RDII control efforts and current issues, concerns and impacts of wet weather conditions on the operations of sewerage systems throughout the Pure Waters districts. In addition to reviewing available information, the project team conducted meetings with the municipalities within the four districts for the purpose of more fully understanding current local sewer service conditions and needs. Following this initial outreach, the project team refined flow schematics of key infrastructure. With these schematics, the districts (Rochester, Gates-Chili-Ogden, Irondequoit Bay-South Central and Northwest Quadrant) were subdivided into 42 sewer basin areas.

An assessment of the preliminary RDII "condition" was performed for the districts and each of their areas within the 42 sewer basins using available flow meter and rainfall gauge data. Flow meters currently located within the collection system and at larger pump stations were utilized for this initial evaluation. The data was examined using computer data analysis programs in the US Environmental Protection Agency's (USEPA's) Sanitary Sewer Overflow Analysis and Planning (SSOAP) Toolbox to determine the response of a specific delineated sewer area to intense rainfall and high groundwater conditions. In addition, the project team utilized the experience of MCDES staff which independently assessed and ranked the "criticality" of each sewer basin area based on the staff's knowledge and past observations relative to wet weather impacts on downstream infrastructure capacity and/or local sewer surcharging. From these RDII condition and criticality assessments, the 42 sewer basins were categorized as follows:

- **Category A – RDII Control Level Adequate –** 20 sewer areas were determined to have adequate RDII control. These sewer areas represent the lowest priority for RDII control efforts.
- **Category B – RDII Control Level Inconclusive –** 17 sewer areas were identified to be of a condition that could not be definitively demonstrated by available data or information. The MCDES staff indicated that wet weather impacts have been moderate to high in these areas in the past. These sewer areas were recommended for additional follow-up study.
- **Category C – RDII Control Level Inadequate –** Five sewer areas were identified where the RDII condition was confirmed with high confidence to be inadequate. The RDII criticality was also judged by MCDES to be high. These sewer areas were confirmed to have sources of excessive RDII, and were identified as a high priority for locating and removing such sources through rehabilitation efforts.

These efforts, evaluations, findings, conclusions and recommendations were detailed in the Preliminary Assessment Report. A five-year schedule was recommended for undertaking the further study of the 22 sewer areas comprising the Category B and C sewer areas.

Coordination with Tributary Communities

Meetings were then conducted with representatives of the local municipalities to initiate open discussion on sewer system conditions and support needs. The meetings were held in a workshop format to facilitate discussion and sharing of information and resources. Each workshop began with a presentation of the study findings and provided the opportunity for each of the municipalities to offer feedback on whether the results were consistent with historical performance and field observations. Many of the community representatives were surprised at how well the analysis identified the problem areas within their systems, raising their awareness and willingness to collaboratively work with Monroe County to address the system-wide RDII problems. As a result, the workshops played a key role in maintaining productive working relationships and setting the stage for further collaborative RDII control efforts within affected towns and villages.

For municipalities with Category C sewer areas, recommendations for source control investigations were presented along with the offer of further assistance to the municipality in on-going evaluation of RDII control and sewer rehabilitative measures. For municipalities with Category B sewer areas recommended for nearer term assessment to better identify the current level of RDII control, an onsite workshop was conducted to present the basis for additional investigations and engage cooperative efforts to implement the work.

RDII Source Investigations for Category C

Several sewer areas were confirmed to have excessive levels of RDII (primarily infiltration) which could produce critical adverse impacts. The MCDES recently completed preliminary field investigations within one sewer area to define the sources and estimate the approximate quantities of excessive RDII. To achieve this, MCDES performed the following work:

- Six portable flow meters were deployed within Sewer Area G1 to divide this area into sub-areas and identify the sub-areas of highest concern and likelihood of locatable and correctable RDII sources. The meters were installed for 14 weeks from early March to mid-June 2013.
- The MCDES staff conducted manhole inspections for up to 330 manholes within Sewer Area G1 to document general flow conditions, manhole conditions and potential RDII sources.

Courtesy of MCDES

The MCDES I/I Team performing system investigations

- The MCDES staff conducted selective sewer cleaning and televising of approximately 24,000 linear feet of sewers (approximately 20 percent of the total footage) to document and reasonably project general sewer conditions across larger sewer sub-areas. Reaches of sewers to be cleaned and televised were selected to provide representative conditions across the entire sewershed, considering sewer age, materials of construction, soil/groundwater conditions and other site specific conditions.
- The MCDES staff conducted selective smoke testing to areas where sewer televising or other information indicated the highest potential for locatable and removable inflow sources, when determined to be beneficial.

Next Steps

Future work will continue to focus on investigations in the other Category C sewer areas. Upon completion of RDII source field investigations for each area, a summary will be prepared that documents the types of locatable and removable sewer defects and RDII sources. The rehabilitation work will be performed by MCDES crews, or packaged together for bidding and construction. Future work will also include additional evaluations of the Category B areas to conclusively define whether RDII control is adequate or inadequate, as well as recommendations for field investigation to identify appropriate rehabilitative measures for satisfying level of service goals. Upon completion of rehabilitative measures, the SSOAP analysis will be run using post construction flow and rainfall data to identify the reductions in RDII and confirm that the sewer service area is operating within the level of service goals established for each district's collection system.

The Pure Waters District-Wide I/I Master Plan is intended to be a living document for the purposes of proactively maintaining the level of service goals for RDII control. This program will also allow MCDES to build a stronger collaborative working relationship with its member communities and better plan capital investments for maintaining a high level of service to its customers for years to come.

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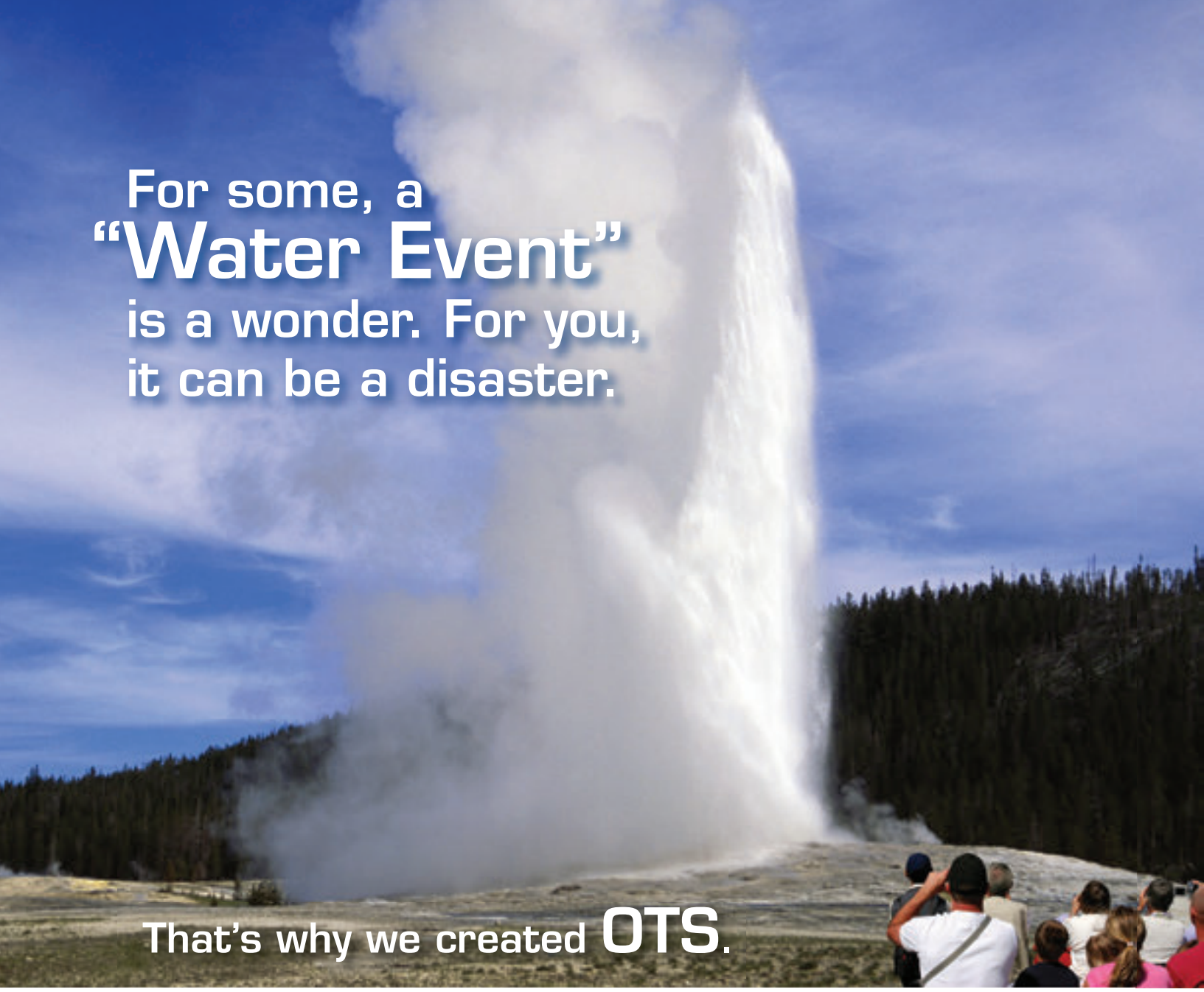

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Effective Asset Management for Optimal Performance Maintenance

by Ryan Johnson

The heart of any effective asset management and maintenance program is knowledge. Knowing what you have, how it functions, how it fails, and how to correctly identify the maintenance objectives and requirements to prevent or mitigate the failures, leads to the extended useful life of the assets and recognizing their functional goals. Three levels of sophistication should be utilized to develop maintenance requirements and these consist of applying the following:

- **LEVEL ONE:** Standard Activities
- **LEVEL TWO:** Maintenance Optimization (Continuous improvement)
- **LEVEL THREE:** Selective Reliability Centered Maintenance (RCM) Analysis

Deciding which to apply is determined by the priorities of the business, the maturity of the operation, time and resource constraints, the criticality of the assets and the level of service requirements established by the client. In general, where speed of deployment is important and assets are low in criticality, standard activities consistent with best practice and vendor recommendations would normally be applied. A high performing maintenance organization then often takes the next step and seeks to optimize its maintenance, particularly for critical assets. At the other extreme, where there are persistent performance, cost or reliability issues or the assets are critical, then full RCM may be applied (on a selective basis).

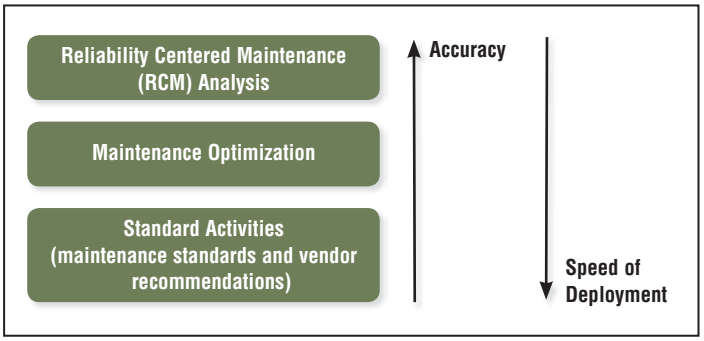


Figure 1: Relationship between Accuracy of Maintenance Outcomes and Speed of Deployment for Maintenance Approaches

The simplest and quickest way to develop a comprehensive maintenance program is through the application of standard activities. This approach is best conducted by an appropriately experienced member of the operations team, preferably a maintenance planner with operator and supervisor support.

The standard approach involves a systematic review of the assets to be managed by identifying the following:

- Statutory maintenance requirements for items, such as:
  - Pressure vessels
  - Boilers
  - Water quality instruments
  - Lifting equipment
  - Flexible hoses
  - Electrical tools, etc.
- Warranty maintenance requirements (for new or recently replaced equipment)
- Vendor recommendations from O&M manuals
- Client maintenance requirements or standards

Once the minimum requirements have been established, they can be assessed for gaps in planned maintenance, particularly for critical assets, which should not normally be run to failure. These gaps should be addressed through a combination of applying standard activities and consulting the vendor or manufacturer.

To assist with this program development, a number of maintenance standards have been created that, given specific asset types, offer recommended routines and frequencies for planned activities, such as inspection, cleaning, lubrication and servicing. These standards also have been developed by Veolia Water on the basis of collected knowledge of failure modes, accumulated operations experience and literature defining best practice techniques. As such, they are a valuable resource for creating maintenance programs from scratch in a reasonably short period of time.

After development of an initial PM (performance maintenance) program, there are sometimes significant opportunities to reduce cost inefficiencies and waste without raising overall levels of risk. These opportunities may be identified through the monitoring of cost key performance indicators (KPIs), such as maintenance spent/asset replacement value or the percentage of maintenance spending that is planned. The methods for achieving efficiencies can vary. For example, a simple maintenance planning and performance review may identify that certain planned tasks within a program are redundant or ineffective and can thus be eliminated. To complement this approach, task packaging can reduce the time associated with performing and recording maintenance activity. Another example is using available data to better estimate the time interval between "potential" and "functional" failure of an asset.

A PM program needs to be reviewed at regular intervals (ideally on an annual basis) for continuous improvement purposes. All changes to the program should be subject to documentation and approval. Doing so ensures ongoing relevance and cost effectiveness of maintenance tasks. An example situation is where one has a 90-day PM calibration on a pH probe, and the technician calibrates on this interval and finds that there is no drift in the accuracy. Sound maintenance practice would increase the interval to the point that the probe has slight levels of drift, thus optimizing the frequency and expense of maintaining the probe not at the expense of the process. The ultimate optimization level could even factor in the seasonal demands and changes to the process and equipment. Before conducting any analysis, it is important first to target only assets that have the potential to benefit significantly through improvements (usually in terms of risk reduction, O&M savings or improved contract performance). Assets that are neither high risk nor high cost to maintain should be excluded from an RCM analysis. Although it is the most time- and resource-intensive approach, RCM is the most accurate method for developing a maintenance program to effectively manage the risks of failures.

It should be emphasized that RCM is a valuable process so long as it is selectively applied to appropriate assets of high quality. The review itself and implementation of the recommendations can have a considerable impact on resources, and thus it needs to be carried out efficiently. To achieve best results, the review must be conducted in accordance with the "classical" RCM methodology, avoiding any shortcuts to the process. The so-called "streamlined" RCM processes that do not comply with the standard should not be used. These risk

continued on page 30

continued from page 29

impacting the quality of analysis, the usefulness of the outcomes and the credibility of the process. Significantly, the RCM review process is only successful if the following responsibilities are assigned:

- Coordination of the review by an experienced, certified RCM facilitator
- Involvement in the review by key members of the contract/operations management team (with knowledge of the operation, maintenance, process and control)
- Assignment of a contract representative to be accountable for implementing the recommendations of the review

The outcome from the Veolia Water RCM approach is an optimized maintenance and spares program. This is based on best practice maintenance engineering and supported by a fully documented audit trail for the future benefit of the company and its clients. The Optimized Critical Spares Program consists of eight key evaluations:

Failure Mode Identification: A "failure mode" is an event that is reasonably likely to occur and that would cause the loss of an asset's functionality. When developing a potential list of spare parts for an asset, an understanding of the equipment at the failure mode level is necessary. The participants in this project have developed a listing of failure modes that are common to each asset type. These lists can be used as guidance materials for evaluating spare part needs. This list is a very good starting point, but there is no substitute for first-hand knowledge of the facility. It is important that experienced operations and maintenance staff participate in the development of the failure modes.

Consequences: Not all failure modes have the same impacts to the operations at a facility. Great care should be taken in evaluating the consequence of failure, utilizing a risk review process. One should make an effort to monetize the risk of lacking a spare part when needed. Staff should build a plant-specific matrix that can be used to quantify lack of equipment availability into money. The purpose of this exercise would be to provide a framework upon which a proper spare part evaluation can be performed. Examples of this approach and its benefits are provided later in this section.

Lead Time: It is critically important to understand the supply chain when it comes to spare parts. The availability and lead time for obtaining spare parts varies significantly based on the manufacturer/supplier and geographical location of the facility. When conducting a critical spares evaluation, one must always fully understand how long it takes to procure an item. Often, excessive lead times may be reason enough to have a spare available at the facility. Initially, a decision may be made not to stock a spare because a redundant asset is available. This decision may have to be reconsidered if one has to rely on solely the redundant system for a long period (while

Step Two: Failure Mode Evaluation

	Failure Mode	Local	System	Plant
1.	Bearing seizes due to lack of lubrication	Bearing wears, gets hot and evantually fails	Bearing wears, gets hot and eventually fails. Standby pump starts and carries load	Loss of Redundancy
2.	Temperature transmitter fails	Transmitter fails and thermal oil pumps stop pumping	Oil system shutdown and OLC initiates a system shutdown	Loss of one train
3.	Heat trace thermostat fails	Heat trace fails, water line freezes resulting in loss of flow	Sludge pumps trip on loss of seal water	Complete plant shutdown

Step Three: Match Critical Failure Mode to Spare

Failure Mode	Spare
Bearing seizes due to lack of lubrication	Bearing
Temperature transmitter fails	Transmitter
Heat trace thermostat fails	Thermostat

Step Four: Determine Spare Cost and Lead Time and Calculated Downtime Cost *(Conversion rate: €1.00 = $1.38)*

Spare	Lead time (in operating hours)	Downtime cost/hour	Cost of downtime due to lack of spare
Bearing	48	EUR_{155}	$EUR_{7,400/event}$
Transmitter	24	EUR_{155}	$EUR_{3,700/event}$
Thermostat	24	EUR_{855}	$EUR_{20,550/event}$

Step Five: Adjust Downtime Cost for Failure Probability *(Conversion rate: €1.00 = $1.38)*

Spare	Downtime Cost (DC) due to Lack of Spare	Failure Probability ***	Downtime Cost Adjusted (DC * FP)	Annual Cost Spare (10 Year Amortization	Storage Cost	Cost per year of Spare and Storage
Bearing	€7,400/event	0.2	€1,480/year	€80/year	€20	€85
Transmitter	€3,700/event	0.1	€370/year	€20/year	0	€20
Thermostat	€20,500/event	0.1	€2,050/year	€40/year	0	€40

Step Six: Evaluate Cost of Spare versus Downtime Cost *(Conversion rate: €1.00 = $1.38)*

Spare	Cost of Spare and Storage	Downtime Cost Adjusted	Spare Required (Yes or No)
Bearing	EUR 85 per year	EUR 1,440 per year	Yes
Transmitter	EUR 20	EUR 370	Yes
Thermostat	EUR 40	EUR 855	Yes

Veolia Environnement North America

Developing a performance maintenance program can help reduce cost inefficiencies and waste without raising overall levels of risk.

one waits for the spare to arrive).

Availability: Often, equipment vendors discontinue product lines and support for products. Some of these changes are the result of market-driven forces, such as mergers and acquisitions within the manufacturing industry itself, while others are purely technologically driven. Special consideration should be given to electronic components such as VFDs and I/O cards. Electronics seem to run a "planned obsolescence" cycle of roughly eight to 10 years. Operations and maintenance staff need to carefully evaluate their options as they relate to spare parts and upgrade paths.

Probability of Failure: A proper critical spares evaluation needs to factor the probability of occurrence into the equation. This is usually done by experienced staff familiar with the common equipment in a similar operating context. There are failure statistics that can also be used to benchmark this type of probability. Understanding the failure rates helps in making a sound business decision as it relates to procuring spares.

Predictability of Failure: Some equipment/components will fail over time due to wear or age/fatigue. It may be possible to properly manage this type of failure by conducting periodic inspections to measure the overall condition of the asset. Components like chains, belts, sprockets, liners and screws can be evaluated for wear, and new parts can be ordered prior to loss of functionality. Each should be evaluated on a case-by-case basis. Properly set up and monitored, condition assessment programs can minimize the amount of spares needed at a facility. Items like fuses, shear pins and electronics fail with little warning and should always be stocked if the asset is critical.

Shelf Life: Some components deteriorate with time (like probes, sensors, ball bearings, batteries and gaskets). These timing considerations should be factored into the decision-making process.

Storage Considerations: Prior to procuring any spare parts, one must evaluate his/her location to determine if the facility has adequate storage facilities onsite. Consideration should be given to environmental conditions (humidity, temperature, sulfides, etc.) and the available space. Staff also needs to ensure that it has the proper systems in place to track the spares and to conduct PM tasks on the inventory if needed (i.e., a spare pump may require that the shaft be rotated periodically to distribute lubrication and prevent shaft deflection). Offsite options should be evaluated and consideration should be given to having the vendors store the parts as a service.

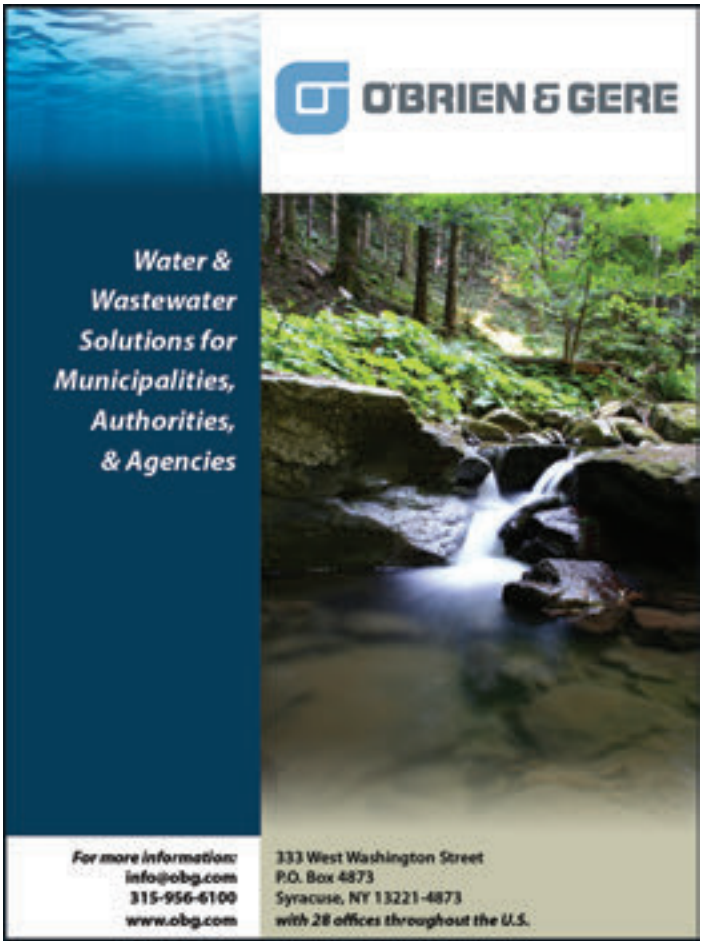
Critical Spares Methodology

Veolia Water developed a critical spares methodology that can be used to assist in making decisions on whether or not to purchase an item. The following is an example of an analysis that was done on a sludge dryer facility in North America. The company operates a sludge pelletizer facility in the United States with a contract that is production-based and includes liquidated damages for downtime and loss of availability. During 2010, a comprehensive reliability centered maintenance (RCM) evaluation was performed at the facility. This review was conducted with both the company's technical and operations staff. The RCM review included a review of failure modes and a thorough critical spares evaluation. A general illustration follows as to how the process was used in six steps to determine the need to stock a spare.

Step One: Monetize the Risk – There are four process trains at this facility and three are needed to meet full capacity. The group determined that if all four trains were unavailable, there would be a EUR 855/hour cost of downtime. The group then evaluated loss of capacity and assigned a lower dollar number for some unit operations (EUR 310/hr). After debating the liquidated damages clause of the contract and its impact on client relationships and more, the group settled on EUR 155/hr as being the cost of loss of redundancy.

The next five steps utilized are described in the comparison tables, ***Steps 2–6*** (on page 30).

Ryan Johnson (ryan.johnson@veoliawaterna.com) is Director of Above Ground Asset Management at Veolia Environnement – North America, based in Chicago.



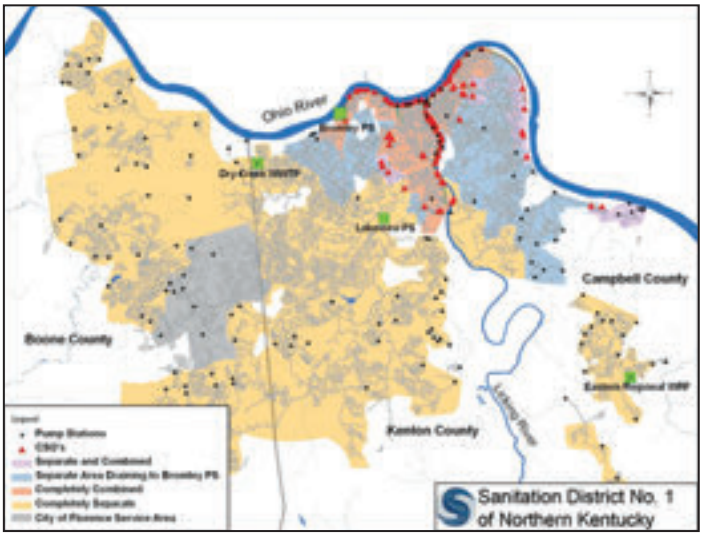
Asset Management Made Easy

Applying Best Business Practices to Develop Practical Asset Management

by Richard McGillis and Brandon Vatter

Sanitation District No. 1 of Northern Kentucky (SD1) provides sanitary and storm sewer services for 33 communities in Boone, Campbell and Kenton counties. This sanitary sewer system covers approximately 200 square miles and serves a population of approximately 350,000. Approximately 1,700 miles of sewer lines and 400 miles of storm lines are maintained with the majority of the collection system being 50 to 100 years old with pipe diameters ranging from eight inches to 120 inches.

In 2005, SD1 negotiated a Watershed Consent Decree with the Kentucky Division of Water and USEPA Region 4 to address its SSOs (sanitary sewer overflows) and CSOs (combined sewer overflows). One key feature of the consent decree requirements was the development of watershed plans every five years. These watershed plans will determine a combination of affordable watershed and infrastructure controls to improve water quality, eliminate SSOs, and comply with the CSO policy. The extent of SD1's overall service area and its combined and separate sewer system boundaries can be seen in ***Figure 1***.



Courtesy of SD1

Figure 1. SD1 Service Area Overview

The district conducted a CMOM (capacity assurance management, operation and maintenance) self-assessment as well as a NMC (nine minimum controls compliance) evaluation. The outcome from this process led to the development of a proactive and comprehensive Continuous Sewer Assessment Program (CSAP) to address both the NMC and CMOM in a singular program. The overall goal of the program was to cost effectively minimize O&M (operation and maintenance) related spills and to implement system renewal and rehabilitation in a way that targets dollars where they have the highest benefit. For the collection system, the benefit was a reduction in both sewer failures and failure consequences, and a reduction in costs due to proactive rather than reactive asset renewal.

The SD1 took the program beyond just the consent decree compliance and asked the question: "What must be done to run a utility well? It answered this question by applying best business practices and designing its asset management program to meet the following key objectives:

1. Develop Goals and Objectives to Accomplish an Overall Asset Management Program
2. Determine Asset Condition and Criticality through Prioritization
3. Define Justified Level of Service (LOS) for the Collection System
4. Determine Lowest Life-Cycle Cost Alternatives for Asset Renewal
5. Define a Long-Term Implementation Plan and Funding Strategy to Accomplish Goals and Objectives

Develop Goals/Objectives for Asset Management Program

The overall goal was to develop objectives that fit into SD1's overall strategic planning, which is exemplified by its Mission, Vision and Core Values. The district explored the following objectives.

Based on the key objectives listed, SD1 explored the following focus areas to define and develop metrics for advancing improvements to its asset management program. It formed a focus group consisting of management, supervisors, and key field staff from engineering, collections systems, operation and maintenance, and public outreach to evaluate and address each one of these areas:

1. **What can be done (even without a consent decree)?:**
   - Improvements could be made to SD1's existing O&M programs and an examination made on how current business management processes could be improved to increase efficiency and reduce capital and operating costs even without a CD.
2. **Customer Service:**
   - What level of service do customers expect?
   - Where do flooding and basement backups occur in the system and how can SD1 mitigate those problem areas?
   - Where are the water quality and public health problem areas in the communities serviced, and how can SD1 programs address the problem areas?
   - Are customers routinely informed about where their rate dollars go and improvements made to service and water quality?
3. **Fiscal Responsibility:**
   - Are the ratepayers' dollars utilized in the most cost-effective manner and are opportunities found to stretch the money to work further and harder for the customers?
   - Is SD1 recording all of the needed cost and O&M metrics necessary in examining opportunities for cost savings as well as operational and productivity efficiency improvements?
   - Is the utility being run like a privately owned business, i.e., constantly examining opportunities to reduce costs, making process

System Objectives	Operational Objectives
Reduce O&M and Energy Costs	Improve Customer Service
Reduce Basement Backups	Transparently Demonstrate Fiscal Responsibility
Reduce Flooding	Proactively Maintain and Renew Assets
Reduce Overflow Volumes and Frequencies	Plan Strategically
Improve Receiving Water Quality	Implement Best Practices

continued on page 35

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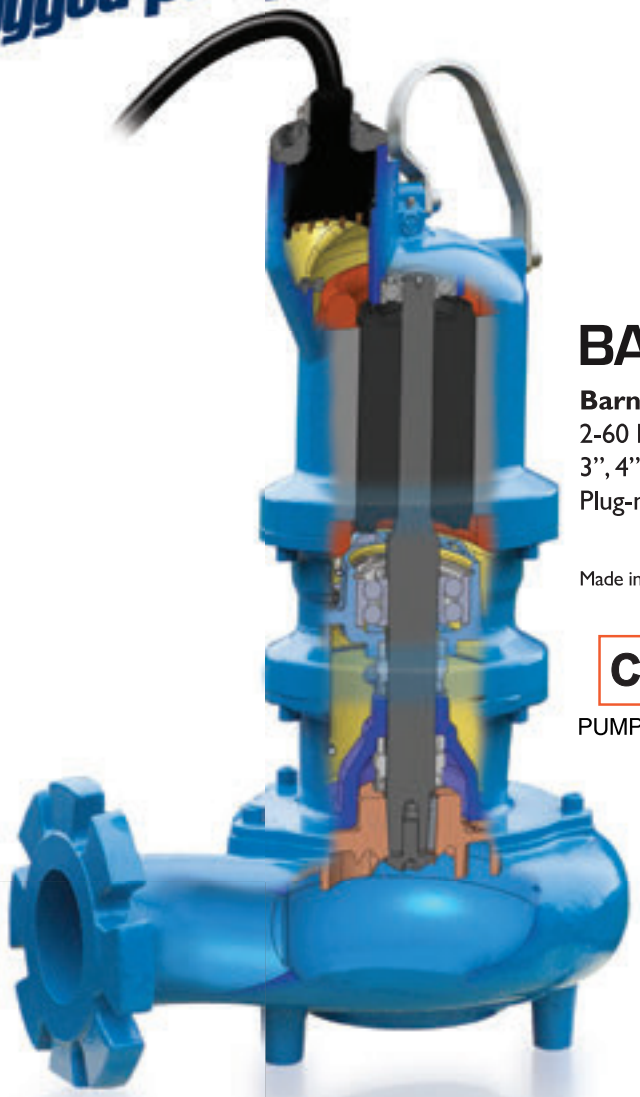

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continued from page 32

improvements (including automation), and increasing efficiencies to maximize the return on the ratepayer's investment?

4. Transparency:

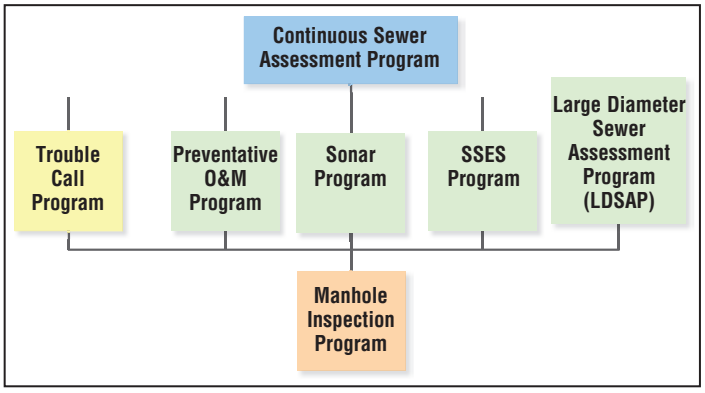
- Can all asset assessment and renewal costs be accurately reported?
- Are those costs reasonable and in line with industry benchmarks?
- Is the utility readily reporting and justifying its costs to the public, its governing body and community stakeholders?

5. Proactive Maintenance and Renewal:

- Is the collection system being maintained and renewed at a sufficient rate to avoid critical failures and excessive costs?
- How can technology and automation be used to maximize maintenance and renewal processes?
- Are asset renewal priorities in line with the goals set forth in SD1's watershed plans?

This step in the program found that the "human element" was the most critical aspect for SD1 in achieving a successful asset management program. The system's leaders realized that it could develop great mechanics and processes for assessing and renewing its collection system assets, but if its personnel – from top management to ground field staff members – do not endorse the need and benefits of the program, it could never be successful. Therefore, gaining each individual's endorsement to the plan and maintaining accountability to it, along with modifying the organizational structure where necessary, were all essential to each step in developing SD1's asset management program.

A focus group was also utilized to prioritize SD1's work. The prioritization consisted of six O&M programs that were incorporated into a larger scale Continuous Sewer Assessment Program (CSAP).



Courtesy of SD1

Figure 2. Overall Structure of Continuous Sewer Assessment O&M Programs

The overall structure of SD1's CSAP is represented in ***Figure 2***.

Each of the O&M components includes an assessment phase followed by an action phase which includes activities, such as cleaning and rehabilitation/replacement. The CSAP program was designed to more effectively and proactively prioritize and implement system inspection, cleaning, and rehabilitation/replacement needs in order to identify and address wet weather I/I (infiltration/inflow) sources, assure sufficient capacity in both dry and wet weather, reduce CSOs and eliminate SSOs.

Using Automation to Reduce Costs, Increase Efficiency

Each sewer and manhole assessed receives a structural and maintenance score from 1 to 100. To help automate and expedite the decision processes of how to use the specific condition assessment scoring results, SD1 developed an automated decision-making process that modeled the staff's decision logic flowchart for addressing different asset condition scores and priority. The automation allowed SD1 staff to readily determine the next assessment or action phase, such as future re-inspection, cleaning, repair, rehabilitation or replacement for each pipe segment based on its received structural and maintenance scores.

The automation allowed SD1 to automatically group pipes by location and write work orders within Lucity™ computerized maintenance management software (CMMS) for ease of scheduling and executing assessment or action work by the field crews. Based on the initial inspection results, typical automated actions are:

- Sewers with high maintenance scores in need of cleaning are cleaned and scheduled for re-inspection in approximately six months to one year.
- Sewers in good condition with no need for cleaning and/or repair are scheduled for re-inspection in one, three, or five years depending on the inspection scores for the pipes.
- Sewers with high structural scores in need of repair are brought into SD1's Rehabilitation/Replacement program to be properly addressed.

Immediate costs and life cycle costs are calculated to help the engineering and collection staff members prepare both short-term and long-term capital investment programs (CIPs) and maintenance budgets and schedules. An example cost report is shown in ***Figure 3***. The bold and highlighted values in the table aid staff to readily determine the corrective action for each pipe segment, providing the lowest immediate and life cycle costs.

					CORRECTIVE ACTION – IMMEDIATE COSTS			CORRECTIVE ACTION – LIFE CYCLE COSTS				
US MAN	DS MAN	Next Structural Task	Process	Remain Life (yrs)	Replace Cost	Repair Cost	Rehab Cost	% More than Maintain	Replace Cost	Repair Cost	Rehab Cost	Maintain Cost
0450009	0450001	Priority 3	**Select Immediate Action**	22	$42,537	$7,923	$15,233		$43,729	$15,446	$20,724	$19,535
0460032	0460030	Fix collapse or Priority 1	**Select Immediate Action**	0	$15,882	$2,888	$6,574		$16,796	$6,465	$9,391	$16,796
0440006	0440005	Priority 2	**Select Immediate Action**	11	$49,644	$22,151	$12,170		$51,554	$31,782	$19,428	$34,466
0460027	0460026	Priority 2	**Select Immediate Action**	24	$13,243	$7,083	$6,040	34	$14,204	$10,392	$8,714	$6,496

Figure 3. Life Cycle Cost Calculations Automated to Generate Lowest Immediate and Life Cycle Costs for Asset Renewal

continued on page 36

continued from page 35

Because of the seamless interaction between GIS (geographic information system) and CMMS, all of the assessment and action data are readily displayed within GIS for quick assessment and decision-making.

Long-Term Implementation

The SD1 Asset Planning Group implements the asset renewal program projects based on the condition assessment previously described. Based on the historical condition data collected, SD1 determined that one percent of the collection system should be renewed annually – or approximately 78,000 feet. This renewal rate requires approximately $7.8 million dollars annually.

The key responsibilities of the Asset Planning Group are:

- Fiscal Responsibility and Transparency
- Coordination between Engineering and Collections
- Corrective Action, encompassing:
  - Prioritization for Proactive Asset Renewal
  - Reactive Work Reduction
  - Data Management and Quality Assurance/Quality Control
  - Three R's – Rehabilitation, Replacement and Repair
  - Cost Estimating and Budget Control
  - Scheduling

The performance of SD1's asset management program could not be accomplished without a motivated and knowledgeable work force. The key to success was developing with staff qualitative as well as quantitative performance goals and metrics. Performance metrics developed within Lucity and SQL Server Reporting Services software show project level performance and annual comparisons, including cost per foot, average costs, estimates versus actual costs, change order tracking, inspection totals, etc.

By seeing performance metrics and goals, SD1 frontline staff have found new motivation and accepted the challenge during their normal work day to exceed past annual averages, identify efficiencies, perform process improvements and cost saving measures. Managers and supervisors are tasked with improving work flow processes and praised for critical and creative thinking. Frontline SD1 staff members, who could combine field application knowledge with wastewater engineering theory, were given new roles in the Asset Planning Group as technicians, planners, schedulers and estimators, without hiring additional staff.

Implementation Results

The SD1 developed a structured framework to managing its sewer system assets in the most fiscally responsible and timely manner.

The SD1 program resulted in:

- Coordinated and efficient asset management of sanitary and storm system infrastructure
- Formation of integrated O&M related programs for CMOM and NMC
- Establishment of performance objectives and integrated data based on business risks
- Calculated life cycle costs for planning and budgeting
- Prioritized inspection and cleaning
- Prioritized rehabilitation and replacement
- Projects for rehab/replacement prioritized by endorsed goals and objectives
- Renewal of existing assets to maximize useful life and reduce operational-related overflows

The SD1's best business practice-based asset management program resulted in the following specific accomplishments:

- Achieved savings of over $725,000 in first year of implementation by reducing the number of pipes on PM (performance maintenance) cleaning list and cleaning pipes only when necessitated.
- Increased in-house CCTV crews from five to seven using existing staff
- Increased in-house inspection production by 110 percent
- Reduced in-house CCTV inspection costs by 25 percent
- Reduced dry weather SSOs by 54 percent
- Decreased dry weather SSOs to 50 percent below industry benchmark
- Increased asset renewal (from 2009 to 2011) by 500 percent and reduced renewal costs by 71 percent

Similar results can be accomplished by any utility, municipality or community wanting to improve its current asset management program.

Richard (Rich) McGillis is the Director of Collection Systems for Sanitation District No. 1 of Northern Kentucky (rmcgillis@sd1.org). Brandon Vatter, PE, is Senior Project Manager with Hatch Mott MacDonald and the former Director of Planning and Design for SD1 (brandon.vatter@hatchmott.com). ***Special thanks are given to Sean Fitzgerald, PE, with Hazen & Sawyer, and Reggie Rowe, PE, and Courtney Kennedy, both with CH2M Hill, for their contributions to the development of this program.***

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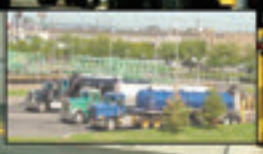

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Oneida County SSO Abatement Project: Use of CMMS and CCTV in CIP Planning

by Yoon Choi, Brian Whittaker, Steven Devan, Joseph Dodd, Jeff Quackenbush and Chris Somerlot

A capital improvement project is an investment. Taxpayers, like any other investor, expect the greatest return on investment. That return should not be measured solely in dollars, but rather, in terms of the triple bottom line of financial, environmental and social consequences. Hypothetically, the initial and ultimate goal for one project may be to reduce inflow and infiltration (I/I) to prevent sanitary sewer overflows (SSOs) and protect the environment. At the same time, the cost of rehabilitation must be taken into account. At a certain point, the dollars spent for I/I reduction provide diminishing returns. How is the ideal I/I reduction versus cost ratio determined to make the best investment decision? The social needs of the community must also be taken into account. There might be pressure from customers in different areas of the community who are demanding higher levels of service for their portions of the sewer collection system. How does one develop the right mix of rehabilitation that best protects the environment and addresses local concerns while wisely spending tax dollars? Sewer rehabilitation modeling, supported by a systematic approach of data collection and analysis, can explore the different scenarios with regard to the triple bottom line and, ultimately, ensure that every dollar is optimally spent.

OCSD Background

The Oneida County Sewer District (OCSD) SSO Abatement Project demonstrates such an approach. The OCSD is located in central New York and serves the City of Utica and the surrounding communities; in total, the Sewer District serves 15 member municipalities. Oneida County owns 45 miles of interceptor sewers, the Sauquoit Creek (SCPS) and Barnes Avenue Pumping Stations, and the Oneida County Water Pollution Control Plant (WPCP). The county is implementing a yearly Sanitary Sewer Overflow (SSO) Abatement Project, aimed at specifically mitigating SSOs at the SCPS.

The project is a result of the settlement of an enforcement action brought on by a New York State Department of Environmental Conservation (NYSDEC) Consent Order requiring that the SSO at the SCPS be brought into compliance with current state regulations.

Studies have revealed excessive I/I as a major cause of SSOs, and Oneida County has committed to reducing I/I as one component of a program to mitigate the SSO at the SCPS. In addition to removing I/I storm and groundwater sources from the sanitary sewer system, the pumping and treatment capacity of the SCPS and the WPCP will be expanded to mitigate the SSO. The county has developed yearly Capital Improvement Plans (CIPs) to achieve these objectives.

With the support of its consultant team, the county embarked on an ambitious sewer asset management program to facilitate the implementation of the SSO Abatement Project. The heart of this sewer asset management program is the existing GIS database created and maintained by the Oneida County Planning Department. The existing GIS included spatial and inventory data, as well as unique manhole ID numbers. The GIS was created by the planning department staff utilizing mapping-grade GPS, beginning around 2000. To date, all of the approximately 5,800 manholes in the SCPS basin, and approximately 10,000 manholes in total, have been GPS located. This GIS forms the asset inventory component of a computerized maintenance management system (CMMS) which is being used to develop a plan that maximizes reduction of I/I while spending limited capital project funds efficiently.

Courtesy of Brian Whittaker, O'Brien & Gere

An open sewer repair in the Oneida County Sewer District

Methodology: Integrating CCTV Inspections with CMMS

The first step of the process involved integrating pipeline CCTV (closed circuit television) inspection records with the county's CMMS. There are approximately 240 miles of sanitary sewer mainline pipe within the 10 communities that are tributary to the SCPS. The county launched multiple contracts for internal CCTV inspections of the pipes in the SCPS basin. The selected CCTV contractors conducted the inspections utilizing the standardized Pipe Assessment and Certification Program (PACP) by the National Association of Sewer Service Companies. Every pipe defect was identified by distance from one manhole and given a rating from 1 to 5, with 5 being the worst. This data was then uploaded to the county's CMMS.

The CMMS software contains a sewer module which includes separate database tables which store pipe inventory information and

continued on page 40

continued from page 39

inspection data. The CCTV inspection database tables are specifically designed to store such PACP records. For every pipe segment televised, an inspection record is created and that record is associated with the pipe. Each of these inspection records contains a list of defects, the locations of the defects, the PACP rating of the defect, and a link to the actual video and photographs of the inspection. There is also an additional feature that identifies the most recent inspection for a particular pipe segment to ensure that only the latest data is utilized for analyses.

Sewer Rehabilitation Models for CIP Planning

Once the CMMS was set up with both asset inventory and inspection data, it was time for assigning an estimated I/I flow contribution for each PACP defect type. This was accomplished using both past I/I studies and the "ASCE Manual of Practice No. 92." As an example, experience gained from past studies indicated that a PACP defect classified as "Infiltration Runner" could cause an average I/I contribution of 1.5 GPM (gallons per minute). Every PACP defect was similarly assigned an estimated I/I flow contribution.

Next, the most appropriate rehabilitation technique was assigned to each PACP defect based on best practice. For example, a PACP defect of "Infiltration Runner" may be best rehabilitated by joint grouting, followed by cured-in-place pipe (CIPP) short liner application. A cost was then assigned to that spot repair based on the pipe's material, diameter and other variables. A joint grouting and a CIPP spot liner repair method for a 10-inch asbestos cement pipe underneath a paved surface, for example, was assigned a specific unit cost. Such unit cost estimates were developed for other potential rehabilitation methods.

The CMMS was then programmed with default triggers to select the most applicable rehabilitation approach, taking into account the cost of individual spot repairs vs. full length CIPP lining. Examples of potential sewer rehabilitation methods are spot repair, full length CIPP lining, a complete pipe replacement, or localized open cut repairs. As an example, if the sum of the spot repairs for a particular mainline sewer were to exceed a pre-programmed percentage (for instance, 50 percent) of conducting a full-length CIPP lining, then the CMMS would automatically default to a full-length CIPP lining as the preferred rehabilitation approach.

Final sewer rehabilitation model results were generated for each sub-basin within the SCPS basin according to these settings. The models contained a list of defects extracted from the CCTV data for each pipe segment, as well as the designated rehabilitation approach, estimated I/I reduction, and the estimated rehabilitation cost for each pipe segment put in a Pipe Analysis Report. All of the individual pipe analysis reports can then be combined to generate an overall report for each sewer shed or sub-basin. The Basin Rehabilitation Report lists all of the pipes in the sub-basin and the associated rehabilitation approach, estimated costs, potential I/I reduction for each pipe segment, and projected I/I reduction per dollar spent.

Utilizing these reports, the county and its consultant team can now objectively decide which basin to focus rehabilitation efforts on to maximize I/I reduction. With the built-in cost estimating features, the county is able to calculate the anticipated rate of I/I reduction per dollar spent. This aids the county in determining the cost effectiveness of rehabilitation projects. For example, it might not make economic sense to achieve an additional five percent of I/I reduction for a particular project if that project consumes an additional 30 percent of the budget. In addition, these reports can be customized and included with bid documents to aid the contractor in bidding on and planning for the actual work. Once the rehabilitation work has been completed, the rehabilitated pipes can be re-inspected and the same modeling process repeated in order to gauge the effectiveness of the sewer rehabilitation.

Rehabilitation Modeling and Results

Oneida County developed multiple models to aid in capital improvement project planning. Specifically, they developed optimized rehabilitation approach tables, estimated costs and estimated I/I reductions for 39 of its basins. Estimated I/I reduction per basin was then summarized and ranked in order of greatest to least total I/I reduction. These rankings were utilized to develop the rehabilitation projects that would bring about the greatest amount of I/I reduction. As a result of this process, the county has the ability to model and optimize the rehabilitation strategy (a combination of spot repairs, full-length lining, and pipe replacement) that will achieve the greatest amount of I/I reduction per dollar spent. In addition, these modeling outputs can be easily modified to serve as pipe rehabilitation schedule attachments in the construction documents for the resulting capital improvement projects.

A systematic and objective approach to planning can help ensure regulatory compliance and justify the expenditure of tax dollars on sewer rehabilitation projects. Oneida County is meeting the challenges of aging sewer infrastructure and a NYSDEC Consent Order by utilizing pipeline CCTV inspections and rehabilitation modeling in its planning process. The sewer rehabilitation modeling efforts helped ensure that the correct rehabilitation methods and sewer sheds were objectively selected to maximize I/I reduction with the best return on the dollar. Specifically, these modeling efforts estimated the amount of I/I reduction, as well as the projected rehabilitation approach and costs.

Through the use of this sewer rehabilitation modeling process, the county is able to efficiently analyze large amounts of inspection data, and utilize this data in the design of sewer rehabilitation projects that cost effectively rehabilitates aging sanitary sewer collection systems. As a result of these rehabilitation projects, excess I/I is reduced, which in turn reduces SSOs in the collection system.

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Establishing Levels of Service for Water and Sewer in Town of Chatham, MA

by Yoon Choi, Mert Muftugil and Sherry Spaulding

Water and sewer utilities across the eastern United States are faced with significant challenges, including aging infrastructure assets, increasing demand for utility services, diminishing financial resources, loss of institutional knowledge from retiring personnel, and increasing restrictions on output through consent decrees and increasing water and wastewater treatment requirements. Asset management serves as an operational paradigm to help balance these needs and justify the cost of operations to customers with ever strengthening resistance to rate increases. More and more utilities are implementing asset management to provide systematic integration of sustainable management techniques with a focus on the long-term life cycle of the asset and its sustained performance.

Figure 1. Balancing Cost, Risk and Levels of Service

Asset management in its core aims to identify the right investment at the right time by balancing the relationship between cost of service, levels of service and business risk exposure ***(Figure 1)***. The establishment of levels of service (LOS) within an organization is a critical component of any asset management program and LOS should be identified whether it concerns a large or a small community, though at varying sophistication levels. Although the resulting levels of service may vary from community to community, the process of identifying LOS as well as the associated benefits, are similar for most organizations ***(Figure 2)***.

Chatham, MA, is a small coastal town on Cape Cod with a population of approximately 7,000. As a major resort attraction, Chatham's population increases dramatically in the summertime and lies within environmentally sensitive areas. As part of a Lucity™ computerized maintenance management system and asset management program implementation project, the Town of Chatham contracted GHD Consulting Engineers, LLC, to facilitate an LOS workshop for the town's water and sewer departments, including water and sewer pipes, pumping stations and the water pollution control facility. The LOS workshop achieved the following objectives:

- Identified the LOS for its water and sewer departments
- Identified the performance measures which help determine how close the town is at achieving the LOS
- Developed a consequence of failure metrics based on the LOS
- Trained the staff on the general asset management concepts and the role of LOS in asset management.

Levels of Service

The definition of LOS is described in the 2011 International Infrastructure Management Manual (IIMM) published by New Zealand Asset Management Support (NAMS) and its international partners, as the outputs a customer receives from the organization. The IIMM further notes that the LOS statements describe the intended delivery objectives, relate to service attributes such as quality, reliability, responsiveness, sustainability, timeliness, accessibility and cost, and note that they should be written in a way that can be understood by the end users. The LOS statements help to:

1. Focus management efforts and resources on well-defined, agreed-upon service levels.
2. Communicate service expectations to customers and stakeholders to better manage expectations.
3. Agree on service level expectations with respect to budget capabilities. Tying LOS directly to budget requirements reduces the disconnect created when there is an expectation of service that is not supportable by budget realities.

The LOS must also be measureable with regards to the following attributes:

1. **Effectiveness –** The degree to which the performance objectives are achieved. Examples include: feet of pipe repaired, replaced or refurbished, versus feet planned.
2. **Efficiency –** The ratio of resources to work performed; typically will have dollars or staffing level as the numerator (inputs). Examples include: operation and maintenance (O&M) dollars per million gallons per day (mgd) treated, O&M dollars per mgd distributed, etc.

Courtesy of ThinkStockPhotos.com

Scenic Chatham Harbor on Cape Cod

3. **Outcomes –** Externally focused measures related to the strategic objectives of the organization. Examples include the percent of customer satisfaction or regulatory compliance. Once the performance measures used for measuring the success of the delivery of the LOS are identified, they should be monitored for sustained or improved performance.

Methodology for LOS

The Town of Chatham developed its LOS in a collaborative process involving the town's water and sewer managers, its contracted maintenance staff, and GHD as facilitators. The joint team was selected for its expertise regarding the town's policies, liabilities (both financial and regulatory) and goals, as well as the functions and conditions of its wastewater and water assets. After receiving training on conducting an LOS workshop, the joint Chatham-GHD team members worked together to develop the LOS statements and the corresponding performance measures. All members were encouraged to participate, share their knowledge and work together to come to a consensus on what the organization's levels of service should be.

Developing LOS begins with a general high level overview approach that ultimately "drills down" to the detailed performance measures. Strategic priorities were first identified. These strategic priorities were documented as high level goal statements. An example of such a statement would be:

"Customer Service – Ensure customer confidence through the delivery of high quantity customer services to the residents."

Once strategic priorities were identified, supporting specific performance measures were identified. Performance measures are tactical measures that tell an organization what it needs to do at a tactical level. As such, they are important, but they are not key to the business. Rather, they help teams to align their performance with strategic priorities. For example, for customer service, a performance measure would be the time that it takes for the organization to respond to a customer service request. Key performance measures focus on those aspects of organizational performance that are most critical for current and future success. Examples include regulatory (permit) compliance, number of sewer overflows, or basement backups.

Results of LOS Workshop

Having identified the LOS, the Town of Chatham now has the capability to match the LOS provided by the asset with customer/stakeholder and regulatory requirements. These expectations deal with the products and services delivered and, more specifically, with the attributes of the products and services – the nature, frequency, content, and quality of products and services. The attributes of the products and services are the levels of service. The target LOS is the level the organization intends to produce; actual LOS is that which is measured. The LOS, cost of service and risk can then be assessed to determine the applicable LOS for the organization. Having established this current LOS, the water and sewer divisions can use it to:

1. Inform customers of the proposed LOS to be offered
2. Develop the annual budget
3. Develop asset management strategies to deliver the required LOS
4. Measure and reward performance
5. Identify the costs and benefits of the services offered
6. Enable customers to assess the suitability, affordability and equity of the services offered
7. Develop objective metrics for determining the assets' consequences of failure

Once the LOS assessment is implemented, it establishes the foundation for the development of the Asset Management Plan that will act as a guide to achieving target goals for the utility involved. Defining these attributes helps to clarify the relationships between LOS, cost of service and risk.

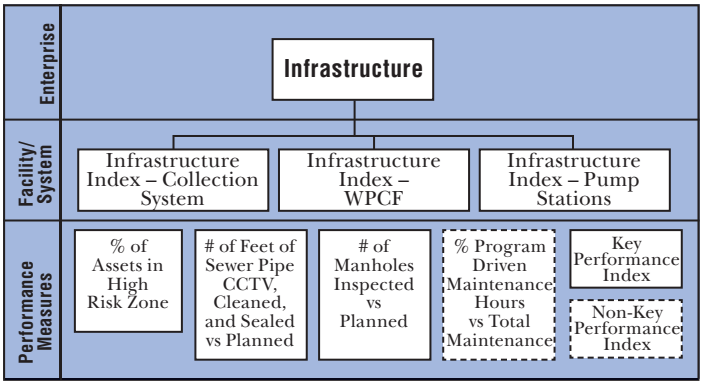

Figure 2. Example of Level of Service – Infrastructure

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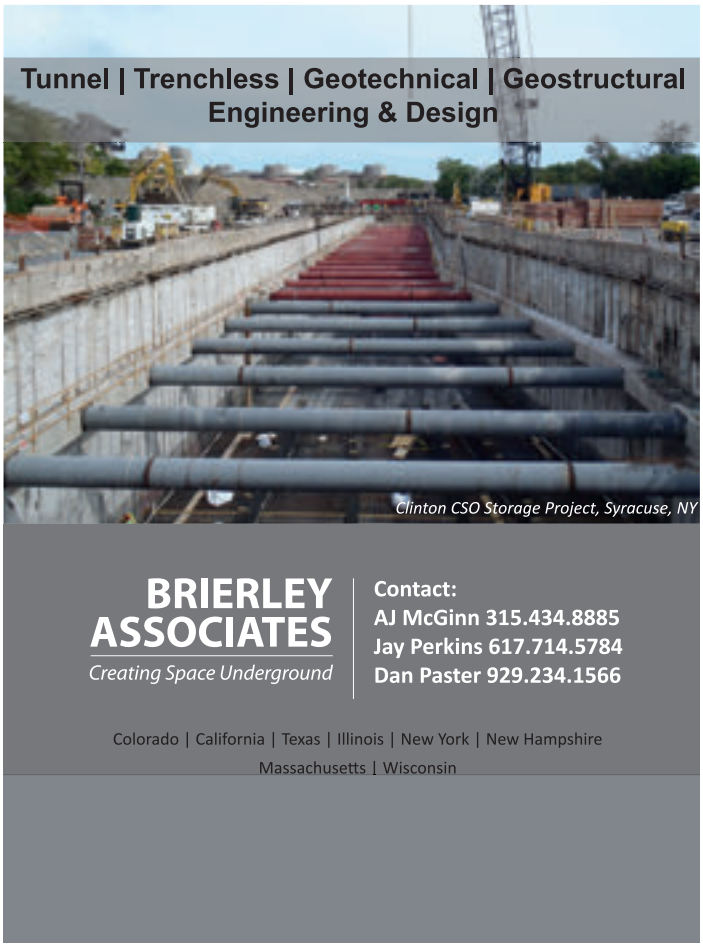

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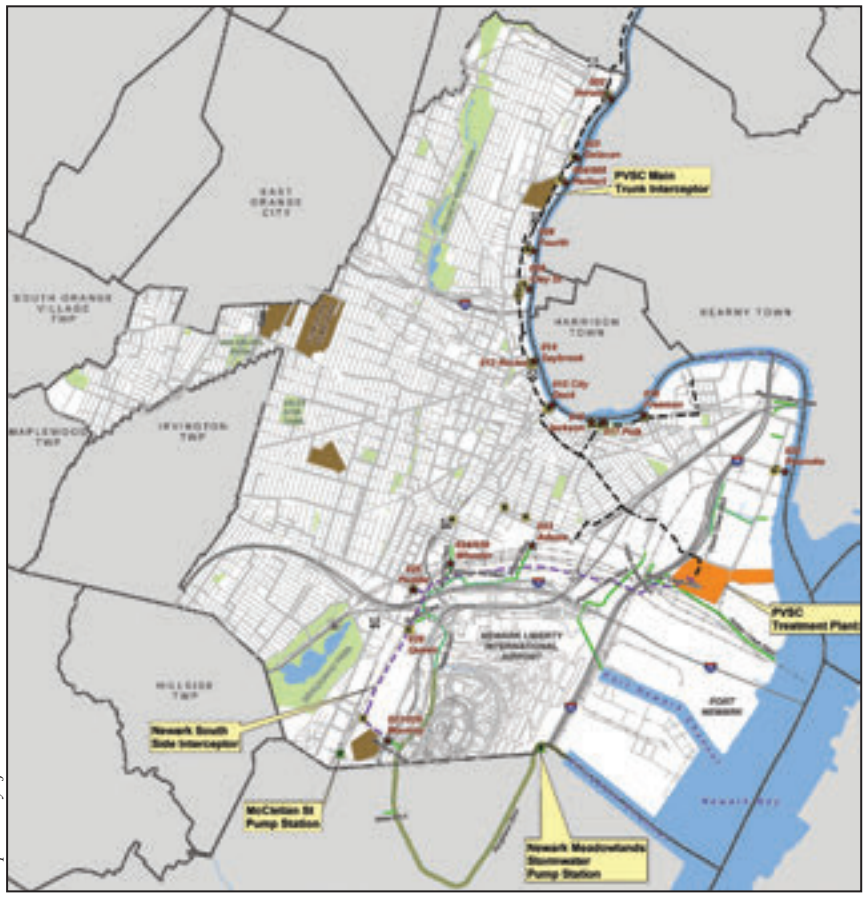
Sewer System Master Planning in Difficult Financial Times: A Newark, NJ Case Study*

by Anthony R. Gagliostro, John J. Scheri, Earl C. Schneider and Joseph F. Beckmeyer

Concerns about aging wastewater and stormwater assets prompted the City of Newark, New Jersey's Department of Water and Sewer Utilities to seek assistance in developing a clear roadmap of actions and capital investments to enhance system performance. By creating a Sewer System Master Plan, the department is able to better demonstrate to city officials the need to improve critical infrastructure. The department is facing several difficult financial realities, including a shrinking workforce, raising non-discretionary costs, and city officials reluctant to raise rates. The master plan is seen as an important tool in obtaining the financial support necessary to maintain and improve the sewer system.



Map courtesy of Hatch Mott MacDonald

The City of Newark, New Jersey's major sewer system facilities

The city maintains approximately 410 miles of sewer pipes (comprising 226 miles of combined sewers, 124 miles of separate sanitary sewers and 60 miles of storm sewers) and the four mile-long South Side Interceptor. Many of the sewers are more than 100 years old and have experienced failures such as structural collapses, pipe deformation, offset joints and sags. Sediment, roots and grease buildup also have blocked flow and created poor connections, which have affected service to residents, businesses and institutions.

City officials authorized department staff to work with a consulting firm in the preparation of a Sewer System Master Plan (SSMP). This plan describes the risks associated with existing infrastructure and recommends a sustainable capital improvements program (CIP), with the goal of providing safe and reliable sewer service to customers. The CIP identifies and prioritizes projects over 10 years based on fundamental planning drivers, such as system renewal, operational performance, and regulatory compliance. The SSMP is one element of the department's 10-Year Strategic Planning Project for overall business improvement. Other elements are a Strategic Business Plan, an Asset Management Plan and a Water System Master Plan.

The SSMP investigation took about five months, beginning in April and ending in September 2010. City officials evaluated the master plan recommendations and there has been much debate regarding the timing of the capital program. New capital expenditure authorizations for the sewer system have been limited to regulatory compliance projects for CSO control and projects with existing funding sources. The Department of Water and Sewer Utilities has focused on educating the various stakeholders on the consequences of further deferring the capital projects for system renewal and building support for the necessary sewer rate increases.

While developing the SSMP, the team considered the city's regulatory requirements. The plan complies with the conditions outlined in the New Jersey Pollutant Discharge Elimination System General Permit for Combined Sewer Systems, the agency's Tier A Municipal Stormwater General Permit and an administrative consent order for CSO Solids/Floatables Control Measures.

Asset Evaluation

The team conducted a data review of existing documents and discussed system conditions with staff. Following analysis of the compiled data, the team determined project needs that would be addressed in a capital program. Among these needs are wastewater and storm sewer rehabilitation, SCADA and CMMS.

Maintenance: Under its maintenance program, the department primarily relies on third-party contractors to clear sewer blockage, inspect the lines, mobilize on-call emergency repair and maintain stormwater pump station and CSO netting facilities. Department staff members clean catch basins in response to street flooding or a customer complaint. Because maintenance and repair information is kept in paper form, the staff cannot easily query or analyze data to measure their service level. In addition, the GIS currently available for the sewer system, especially the non-brick sewers, is limited in extent and function. The department needs to improve its sewer mapping, data management and document retrieval system to be able to determine how many maintenance activities are planned or are in reaction to system failures. A CMMS for all activities, including work by third parties, would promote more effective and efficient maintenance.

Brick Sewers: For more than 20 years, the city has invested in evaluating and rehabilitating its brick sewers. Now in Phase VI of the

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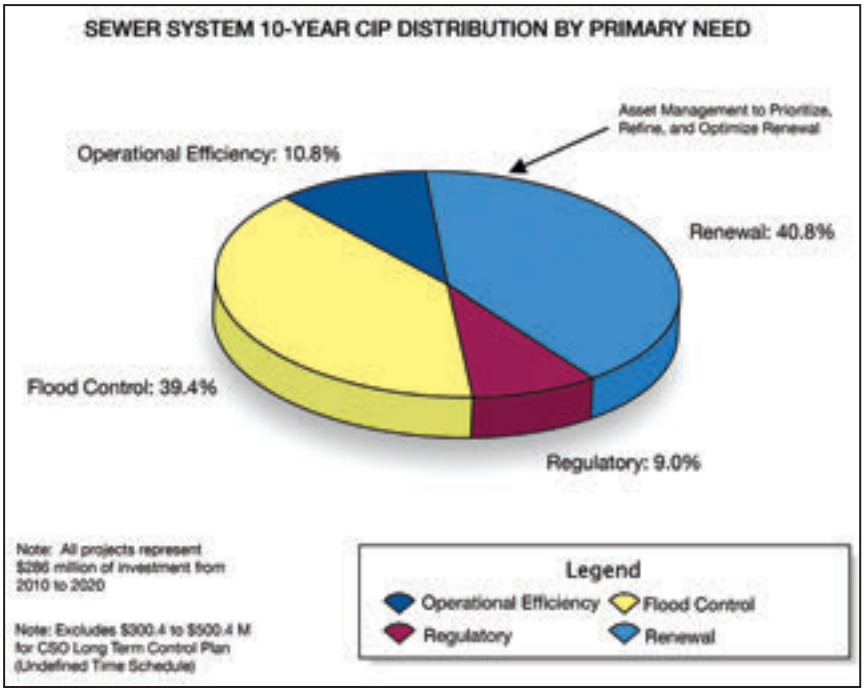

program, the city expects that about 37 miles of brick sewers will have been rehabilitated at a construction cost of about $100 million upon completion of the current phase. This represents approximately 56 percent of the total brick sewers within the city.

Blockages and Emergency Repairs: Records review showed that with the brick sewer rehabilitation program in place, most of the recent blockage clearing and emergency repair requirements were associated with non-brick sewers. Records from 2001 through 2010 indicate that more than 95 percent of the emergency repairs involved non-brick sewers 46-cm (18-in.) in diameter and smaller. This analysis also revealed that the cost of emergency repairs was significantly more expensive than planned rehabilitation and replacement projects.

The department inspected 52 pipe sections in 2008 using a truck-mounted zoom camera and although based on a limited number of inspections, the study showed that at least 20 percent of the sewer collection system may require heavy cleaning (based on observed operational deficiencies) and 12 percent may need structural rehabilitation.

System Needs: The proactive brick sewer inspections resulted in a prioritized renewal program that restored structural capacity and lowered the overall risks associated with operations. The team recommended that the department consider a similar program to inspect, assess the condition of, and rehabilitate the nonbrick sewers.

The department needs to assess the condition of the South Side interceptor with a thorough evaluation, including closed-circuit television inspections and physical entry for structural and mechanical condition assessments of the pipe, manholes, flow metering and regulator diversion chambers, and associated equipment. Some amount of rehabilitation of the interceptor likely will be necessary.

New Jersey's environmental agency has ordered the city to complete floatables control facilities at its 15 active CSO points and 10 have been built or are under construction. Land acquisition issues have delayed construction of the remaining five facilities. Complying with this order is a high priority for the capital plan as well as addressing minor structural and mechanical deficiencies in the CSO control facilities and outfalls.

The team identified only moderate investment needs for the stormwater pumping stations, involving equipment rehabilitation and the addition of a SCADA system.

Like the interceptor, the actual structural and operational condition of the stormwater collection system is unknown. City staff reported that clogged catch basins and blocked or collapsed storm drains are relatively frequent. To help avoid street flooding and provide an engineering basis for system improvements, the city must develop an assessment and rehabilitation program for its storm drains and catch basins. Such an assessment should determine which drains and basins require cleaning, repair, lining or replacement, in accordance with Tier A permit requirements.

Some of the stormwater drainage channels are characterized by limited hydraulic capacity, heavy sediment buildup, undersized conveyance structures, unstable bank slopes and known or suspected sediment contamination. To effectively identify the most critically required improvements, the department needs to conduct a thorough and comprehensive analysis of the overall drainage system.

Photo courtesy of Hatch Mott MacDonald

Performing structural rehabilitation of a large diameter sewer by gunite coating

Capital Improvements Program (CIP)

The team's CIP identified 22 projects. These were divided into renewal and replacement, regulatory requirement, flood control or operational efficiency categories. The total estimated cost of the projects for the 10-year planning period, excluding potential expenditures that may be required to implement CSO Long-Term Control Plan projects, is approximately $286 million (2010 dollars).

continued on page 48

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continued from page 46

This figure incorporates approximately $116.6 million for the renewal of the sanitary, storm and combined sewer systems, including the interceptor and existing CSO control facilities and outfalls. Projects estimated at $25.7 million were included under regulatory compliance for the completion of the CSO Floatables Control Facilities. The projects covered under the $114.3 million for flood control include restoration and improvements to the stormwater drainage ditches and upgrades to the pumping stations. The $30.9 million for operational efficiency improvements includes sewer maintenance and inspection equipment and meter installations for flows to the regional wastewater treatment facilities. The total estimate does not include any expenditure for undefined future CSO control requirements, which may represent a liability between $300 million and $500 million. The SSMP does consider the financial liability of the city to comply with further CSO requirements; however, only a broad range of potential cost expenditures could be prepared without knowing specific treatment objectives and control measures.

The team distributed $81 million of the system renewal and replacement total to annual renewal projects over 10 years. Consistent and sustainable investment in sewer inspection and rehabilitation projects will ensure reliable sewer service in the future. Renewal projects, including cleaning and inspecting non-rehabilitated brick sewers, manholes, catch basins, storm drains, and half of the non-brick sewers, will enable the department staff to identify and address sewer problems before loss of service and allow advanced rehabilitation planning. In this manner, the department gradually will stop reacting and start searching for problems before they affect service. The SSMP sets a renewal schedule that corresponds to cleaning and inspecting about 20 miles of sewers and rehabilitating about 4.0 km (2.5 mi) of sewers annually.

The team recommended the department approach sewer evaluation and rehabilitation programs in three phases: develop sewer inspection plans, assess sewer conditions, and prioritize and implement rehabilitation needs. The department must first inventory its buried assets, develop critical sewer criteria, and categorize the sewers into groups according to their criticality. Criticality ratings are based on a sewer's importance to the system and the potential impact if a failure occurs. In this planning phase, the department will review system records and establish priorities for detailed investigations. Other planning phase activities include evaluating rehabilitation options for various components, developing cost matrices for various alternatives, and establishing a consistent solution to address each type of anticipated problem.

Cost of Reliable Service

The team evaluated the impact of the proposed CIP on sewer rates, assuming funding with NJEIT (NJ Environmental Infrastructure Trust). The Master Plan found that implementation of the proposed projects over the 10-year planning period represented an increase of approximately 2.7 percent per year from the 2010 funding level, without considering increases due to existing debt service or cost-of-living adjustments (COLA).

However, increases in the city's existing sewer debt obligations for previous and current sewer infrastructure improvements will affect the department's budget in the upcoming years. The city's existing sewer system debt service increased substantially in 2011 and will continue to rise through 2014, and then level off at about $6.4 million per year from 2016 through 2025. Taking into account inflation for operating expenses, construction costs, and the existing debt service, the team calculated that an initial increase of 11.5 percent would be required to cover the jump in the existing debt service and the debt service for the proposed CIP. Thereafter, the average sewer rate increase was estimated to be approximately three percent per year, which does not include COLA and regional wastewater authority adjustments.

Finally, as part of the initial strategic planning efforts, the team identified other tools to help the department measure progress and improvements, including customer satisfaction surveys, service level measurements, replacement curves, risk assessments, life-cycle cost management, workforce evaluation and asset management systems.

After the department completes its data-gathering projects to further define system operation, maintenance and rehabilitation needs, the city should invest in GIS and CMMS to organize an asset inventory and hierarchy, document and grade asset condition, and monitor the balance between planned and unplanned maintenance. The SSMP should minimize expenditures while achieving the desired level of service and maintaining reasonable and justifiable user rates.

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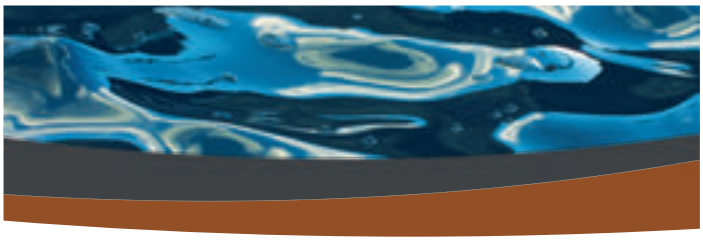

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Public Opinion on Water and Wastewater Infrastructure Issues

by Sridhar Vedachalam, David L. Kay and Susan J. Riha

This article originally appeared in the Cornell University Community and Regional Development Institute's (CaRDI) Research and Policy Brief Series, Issue 56, October 2013.[1]

What is the Issue?

Water and wastewater infrastructure (W&WI) in the US is in need of immediate capital investment. Much W&WI has aged past its expected useful life even as new capacity challenges loom. Support from the federal government for W&WI has declined significantly in the last two decades, forcing state and local governments to contribute a larger share. With increased decentralization of infrastructure decision-making, public opinion is playing an ever greater role. Preferences measured through public opinion surveys, coupled with preferences revealed by ballot and market choices, can offer policymakers a broad understanding of public support for various W&WI policy alternatives. Questions on capital investment, privatization, and concern for W&WI were part of a national public opinion survey conducted in 2012. We discuss the results of the survey and some associated policy implications.

Water and Wastewater Infrastructure

Water and wastewater infrastructure (W&WI) in the US is aging. According to recent USEPA reports, more than $630 billion will be needed in capital improvements over the next 20 years to ensure safe drinking water ($335 billion) and clean rivers ($298 billion) in the nation *(USEPA, 2008; USEPA, 2009)*. Annual federal funding for construction and improvement of W&WI has remained fairly constant at around $2.5 billion since 1987. After accounting for inflation, this means that the real value of this limited funding has declined significantly, all while needs have increased year-on-year (*Copeland, 2012)*. Over the same time period, some states have seen a dramatic reduction in federal funding for wastewater treatment. For example, New York received $227 million in 1991 for the Clean Water State Revolving Loan Fund (CWSRF), which fell to $75.1 million by 2008 *(NYSDEC, 2008)*. Although the general decline in federal funding has affected all municipalities, small- and medium-sized utilities are the most impacted since they rely more heavily on federal funding. Through direct loan financing and repayment of the SRF loans, ratepayers pay about 90 percent of the capital costs for W&WI *(Copeland and Tiemann, 2010)*. The trend toward decentralization of W&WI funding decisions has necessitated increased incorporation of local public opinion in decision-making. Subsequently, the influence of local public opinion in shaping infrastructure decisions has evolved. A study of the 2001 municipal elections in Florida, for example, found the defeat of incumbents was tied to their positions and decisions on infrastructure issues. However, like any other topic, public opinion on infrastructure and government involvement is malleable, responsive to events, and subject to issue framing. In 2012, we included three questions on W&WI in the Cornell National Social Survey to identify public opinion on certain key issues against the backdrop of aging infrastructure. The survey was conducted over phone, yielded 1,000 respondents (18 percent response rate), and is broadly representative of public opinion nationally.

Photo by Brian Rahm, NYSWRI/Cornell University

Reductions in Clean Water State Revolving Funds affect the maintenance and improvement of wastewater treatments plants, such as this one shown serving Ithaca, NY.

Where Should the Funding Come From?

Respondents were asked their preference among four possible sources for funding for large capital investments in W&WI (see ***Table 1*** for the options provided). A larger proportion of respondents preferred funding from local governments compared to state or federal governments. This is consistent with surveys showing that even though overall trust in government has been declining for the past three decades *(Tolbert and Mossberger, 2006)*, local governments have consistently enjoyed higher levels of trust as compared to other levels of government *(Kelly and Swindell, 2002)*. Statistical tests suggest that party affiliation was the strongest demographic predictor of responses. Republican respondents' preference for private corporations exceeded that for local and state governments, each of which was in turn significantly preferred over federal W&WI funding.

Table 1: Respondent preferences for the source of funding for water and wastewater infrastructure (W&WI) projects

Source of Funding	Respondents (%)
Federal government	18.3
State government	28.2
Local government	40.0
Private corporation	13.6

Number of respondents N = 926.
Respondents (%) total exceeds 100.0 due to rounding

Voter behavior regarding W&WI policy is also instructive. In the face of declining federal support for W&WI over the past decades, state governments have stepped up their support through grants/loans, bonds, taxes and other means, though they have been unable to close the funding gap. Since 2001, 25 statewide ballot initiatives have been introduced across 11 states to finance W&WI with an overwhelming degree of success *(IRI, 2013; NCSL, 2013)*. Maine has used ballot initiatives to raise capital for W&WI financing most frequently during this period, though some larger states have raised a much greater amount through single initiatives. Of the 25 initiatives, 12 were placed on the ballot by Democratic governors, 10 by Republican governors and the rest by Independent governors,

continued on page 55

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continued from page 53

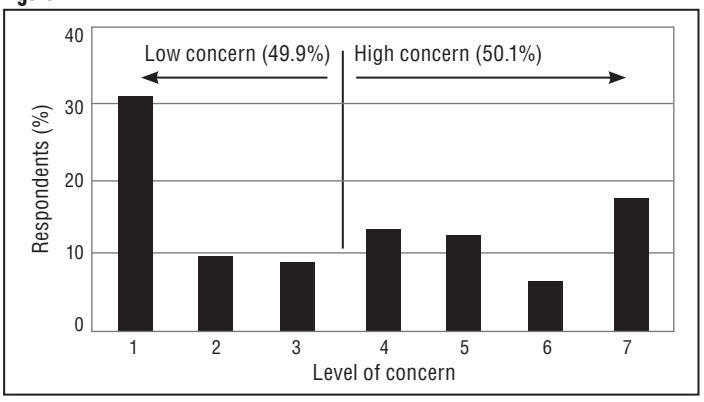
demonstrating cross-party support for W&WI financing at the state level. Twenty-two initiatives were successful, getting an average of 60 percent votes in favor of the proposition.

Is Privatization a Popular Option?

Respondents were asked to indicate who is best suited to manage W&WI: (i) private corporations, (ii) public water and sewer boards, or (iii) both are equally suited. A plurality of the respondents (44%) felt that both public and private entities were equally suited to manage W&WI such as treatment plants. The remaining respondents preferred public water and sewer boards (38%) over private corporations (18%). Statistical analysis again revealed a divide along party lines – private providers were more likely to be preferred by Republicans and strongly disfavored by Democrats as compared to independents. Conversely, public water and sewer boards found less support among Republicans over Democrats and independents. These results are broadly consistent with the complex relationships between political ideology, support for privatization, and privatization policies. For example, Morris and Travis (2003) found that comparatively conservative or Republican-controlled states were more likely to privatize aspects of the Clean Water SRF program, while Warner and Hebdon *(2001)* concluded more generally that "pragmatism wins out over politics" in local government privatization decisions.

Market research shows that consumers who are unsure and do not have strong preferences pick the "middle" option *(Kamenica, 2008)*. With a few exceptions, Americans do not have extensive experience with privatization of water and wastewater services. The fiscal situation in many municipalities has forced communities across the US to look at alternative ways of financing W&WI, including privatization. Knowledge about the pros and cons of both private and public management could help consumers make appropriate decisions. Further research could investigate if increased familiarity with water privatization leads to more or less favorable preferences toward such arrangements.

Figure 1



Level of Concern

In the last few years, reports on the deteriorating state of W&WI across the country have been issued by various government and non-government policy agencies and industry groups. Except for the treatment plants, much of the W&WI is subsurface and suffers from the "out of sight, out of mind" syndrome. A water main break, boil water advisory or a sewage spill exemplify some of the few instances when public concern for W&WI is evident. General public opinion on the state of W&WI has been sparsely measured. To address this deficiency, our survey respondents were asked to indicate their level of concern toward W&WI in their community on a 7-point scale. Responses were fairly evenly distributed, with a slight skew toward the "not concerned" end of the scale ***(Figure 1)***. Suburban, single and older respondents are more concerned about the state of W&WI, whereas Republicans and white respondents are less concerned. The higher concern expressed by suburban respondents is notable, since most urban areas contain older infrastructure as compared to their suburbs.

To compare these scores across metropolitan areas comprised of both urban and suburban residents, the individual scores for level of concern were aggregated by metropolitan areas and paired up with other datasets measuring "ease of access to safe and clean water" *(Witters, 2010),* and water rate increases between 2001 and 2012 *(McCoy, 2012)*. Using the 35 largest metropolitan areas for which complete data was available, we found that higher levels of concern were associated with both lower perceived access to clean water and to larger increases in water rates. Both associations are sensible, and the correlation with water rates indicates that prices are potent signals that convey information about the state of infrastructure to the residents. Increasingly, utilities are implementing "full-cost pricing," i.e., passing on all costs to the end customers, becoming proactive about infrastructure upgrades, and facing weather extremes, all of which have resulted in significant, but necessary increases in water rates. While rising levels of concern may follow a rise in rates, this connection can be mitigated to some extent through education and outreach by local utilities.

Conclusions

Our study assessed public opinion on three key issues relevant to W&WI – financing, privatization and overall levels of concern. Party affiliation was a significant explanatory variable on all three survey questions. Other demographic variables proved occasionally important, but were less consistently significant across the models in their ability to explain public opinion about financing, privatization and concern. Although there is little disagreement among policymakers on the need for significant investments to upgrade and maintain the W&WI in the US, there is no clear consensus on how to go about making those investments. As local governments have been forced to assume greater responsibility for infrastructure financing, local elected leaders are increasingly judged by their positions on infrastructure. Preferences measured through national surveys of public opinion, coupled with preferences revealed by voting and purchasing decisions provides policy makers, even at the state and local level, with a broad base of understanding of the starting points of public support they must contend with when they advance various kinds of policy alternatives. Simultaneous efforts to foster a well-informed electorate and to encourage a responsive government are important if our society is to address the increasingly urgent and complex challenges facing the water and wastewater sector.

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[1] ***Editor's Note:*** *This is the abridged version of the original article, "Capital Investment and Privatization: Public Opinion on Issues Related to Water and Wastewater Infrastructure" that appeared in Public Works Management and Policy, published online October 8, 2013, by Sage Publications, available at: http://dx.doi.org/10.1177/1087724X13500240.*

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Operator Quiz Test No. 102 – Biological Treatment

The following questions are designed for trainees as they prepare to take the ABC wastewater operator test. It is also designed for existing operators to test their knowledge. Each issue of *Clear Waters* will have more questions from a different section of wastewater treatment. Good luck!

1. If an in-tank dissolved oxygen (DO) probe is improperly calibrated at an aeration tank resulting in lower values than actual, what result is most likely?
   a. Not enough DO will be provided for nitrification
   b. The aeration blower will not be providing enough DO to the microorganisms
   c. The aeration blower will be running more than required wasting energy
   d. Low DO filamentous bacteria are likely to form

2. If a large dairy discharges a much higher than normal organic load to the sewer system, the operator's first indicator is:
   a. A decrease in the DO concentration in the aeration tank
   b. Floatables in the final clarifier
   c. BOD in final effluent has increased
   d. Sludge production has increased

3. Why are the horizontal pipes holding air diffusers at the same elevation in an aeration tank?
   a. To provide a tapered release of air into the reactor
   b. To accomplish complete mixing
   c. To ensure diffuser clogging does not occur
   d. For an even air release into the reactor

4. If there is insufficient withdrawal of settled sludge from a secondary clarifier, what can occur?
   a. Sludge rising to the surface
   b. Presence of gas bubbles in the clarifier
   c. Turbid effluent
   d. All of the above

5. Rotating Biological Contactor (RBC) Units are usually installed in a concrete tank so that the surface of the wastewater passing through the tank almost reaches the shaft.
   a. True b. False

6. If there is no oxygen present and all biological activity within the pond is anaerobic, this is known as what type of pond?
   a. Aerobic pond
   b. Anaerobic pond
   c. Facultative pond
   d. Aerated pond

7. What is the watery mixture of microorganisms and solids removed from the settling tank called?
   a. Mixed liquor suspended solids
   b. Mixed liquor volatile suspended solids
   c. Mixed liquor
   d. Activated sludge

8. A 2,000 mL sample of activated sludge is allowed to settle for 30 minutes. At the end of 30 minutes, the sludge volume is 1,100 mL. What is the 30-minute settled sludge volume (SSV30)?
   a. 552 mL/L
   b. 550 mL/L
   c. 110 mL/L
   d. 475 mL/L

9. What are the chemicals called that are released by microorganisms in the biological treatment process that break down adsorbed food particles?.
   a. biomass
   b. enzymes
   c. sulfides
   d. chlorides

10. The measurement of oxygen required during the stabilization of decomposing organic solids by an aerobic process is:
    a. biochemical oxygen demand
    b. dissolved oxygen
    c. ozonation
    d. chlorination

11. What is the best description of nitrification?
    a. ammonia is converted to COD
    b. nitrites are converted to ammonia
    c. ammonia is converted to nitrites and nitrates
    d. nitrates are converted to ammonia and nitrites

12. Advantages of a pure oxygen activated sludge process include:
    a. smaller aeration basins are required
    b. ability to handle shock loads
    c. decreased solids production
    d. all of the above

Answers on page 61.

For those who have questions concerning operator certification requirements and scheduling, please contact Tanya May Jennings at 315-422-7811 ext. 4/tmj@nywea.org, or visit www.nywea.org/OpCert.

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or by calling (315) 342-8159 or at www.oswegony.org

Applicants must live in Oswego County at time of appointment.
Applications will be accepted until position is filled.

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Town of Springwater

Minimum Qualifications: Five (5) years of progressively responsible experience in public works or related construction activity, two (2) years of which must have been in a supervisory capacity and graduation from high school; or graduation from a recognized college or university with major work in civil engineering or a related field and one (1) year experience in public works or related construction activity; or any equivalent combination of experience and training.

Special Requirements for Acceptance of Application: Eligibility for or holder of, appropriate water treatment and purification plant operator's certificate and sewage treatment plant operator's certificate issued by the State of New York. Possession of the certificates is required at the time of appointment.

Duties: This is a difficult technical and administrative work involving responsibility for directing, coordinating, and inspecting the operation and maintenance of wastewater and water systems, parks and recreation areas, town buildings and facilities. The work is performed under general supervision in accordance with established policies, and is reviewed by inspection by the Town Board and through reports. Supervision is exercised over the work of all departmental personnel.

Interested parties should contact: The Springwater Town Clerk during regular window hours, either in person at 8022 S. Main Street, Springwater or by calling 585-669-2545.

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Contact Maureen at mgk@nywea.org.

Answers from page 59:
1c, 2a, 3d, 4d, 5a, 6b, 7d, 8b, 9b, 10a, 11c, 12d

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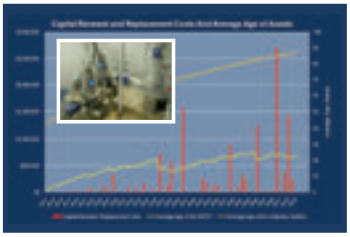

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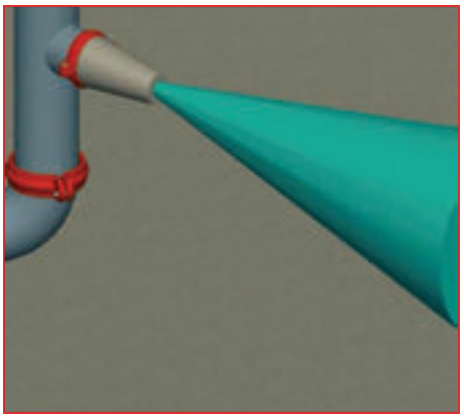

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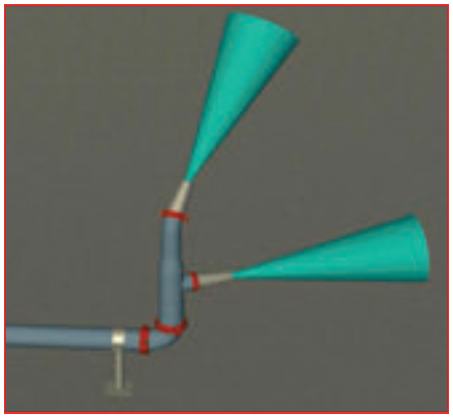

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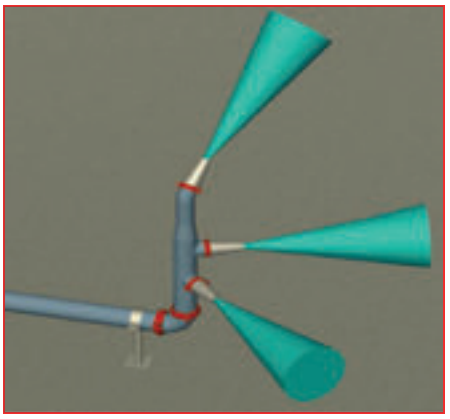

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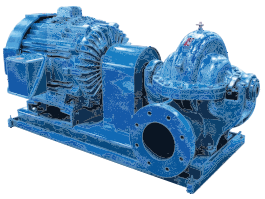

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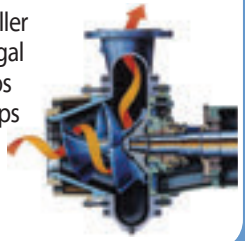

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